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Tuan
Nguyen

THE UPGRADE AFFAIR

I'LL NEVER FORGET the joy I felt on the day I opened my first multimedia upgrade kit. In it was a soundcard, CD-ROM drive, and a pair of speakers. I was so excited—mainly with the prospect of not having to continue listening to the clicks and beeps from my "PC speaker." It was my first step into upgrading.

That was back in the early '90s. These days, we have so much more to play with: SSDs, graphics cards, CPUs, RAM, keyboards.... If you're just getting into the components game now, the list of things you can upgrade is endless. But what about stuff outside of the PC? Sure, you can keep throwing things inside the box to make it more powerful, but things outside can enhance your overall experience, too.

Recently, I've started to include my environment as being part of my entire computing experience. Whether that's an electronically adjustable desk, voice-activated LED room lighting, or creating a killer network setup, everything that surrounds you can be taken into account.

I've pretty much done everything I can to my room, save for installing automatic sliding doors. But as much as I've done, I still feel there's always more to do. I can't stop tinkering and building. When I moved into my current place, I gave myself a mandate: Go simple, clean, minimalistic. Turns out, I failed miserably with that. My room turned into a server room that rivals those from many small and medium-sized businesses. And guess what—I love it.

I'm actually in the process of considering a complete upgrade to my system. Although my specs aren't horrible by any stretch, they are getting a little dated. I'm using a system based around a Core i7-4960X, with 32GB of DDR3 Samsung "green" RAM. I know—these components can still cook, but there have been instances when I've run out of memory. Unfortunately, to solve my RAM dilemma, I'm going to have to gut the entire system.

First, the motherboard would come out. It's an Asus X79 Rampage IV Black Edition, but it's got strange quirks that annoy me, such as constantly not being able to enumerate the keyboard during POST. It's served me well for years, but now it's time to move things into the X299 realm. I haven't decided what CPU I'm going to need, but I never felt that I was starving for CPU power. What I'm actually craving is simply more of the same experience.

There have been times when I've actually had some doubts. I thought I would outgrow my fancy for all the PC stuff, and just get myself a simple, ready-to-go system instead. I've certainly had my fair share of frustrations and near-endings, but like any great relationship, it's only gotten better with time.

I'm still in love with you, PC.

Tuan Nguyen is Maximum PC*'s editor-in-chief, also known as "the pointy end of the stick." He's been writing, marketing, and raising hell in the tech industry for 20 years.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Mixed Reality Hardware Arrives

Windows gets ready to embrace integrated VR

"WITH WINDOWS mixed reality, you can escape the everyday into a world of imagination." According to Microsoft's sales pitch, at least. Mixed reality is the headline act for the Window 10 Fall Creators Update. The first five headsets have been unveiled, and will be ready to buy by the time you read this.

Why use the term mixed reality instead of virtual reality? Because the headsets all have front-mounted cameras, which enable the blending of the real world with the virtual one. This enables some neat tricks. Your virtual world could include subtle boundary markers taken from the physical world, to stop you blundering into the scenery. At the other end of the scale, it can present a view of the real world, with added avatars and virtual elements, *Pokémon Go* style. The cameras also enable the tracking to be done entirely on the headset—no external tracking cameras are required, so any area is the play area.

The new headsets all follow a similar pattern, with variations in ergonomics and build quality. The prices are a little higher than we had hoped. There was talk of $299 headsets, which haven't materialized yet. The Acer MR Headset and Dell Visor are $399, the Lenovo Explorer and HP MR Headset are $449, while Samsung's Odyssey weighs in at $499. The first four have similar basic hardware specifications, with two 1440x1440 screens, and a 90Hz refresh rate. The Samsung boasts fancier 2880x1600 OLED screens—impressive. All use the same wireless motion controllers, studded with LEDs to enable tracking. Headphones and microphones are notable omissions.

Hardware requirements depend on the mode. MR can run in Regular and Ultra modes. The lower mode, using integrated graphics, isn't to be recommended; the refresh rate drops to 60Hz, which can quickly lead to VR's Achilles' heel: nausea. Regular mode requires a Core i5-7200U or better processor with HT, and integrated HD 620 graphics or better. Ultra mode needs a Core i5-4590 quad-core CPU, and an Nvidia GeForce GTX 960, AMD Radeon RX 460, or better graphics—fairly chunky, but not as demanding as rival virtual reality systems.

What can you run on your new MR headset? Quite a bit: some top titles from the Microsoft Store, including *Minecraft VR* and *Halo Recruit*, as well as access to titles from SteamVR. These headsets have the weight of Microsoft Windows behind them, so expect support to be much more robust, and with strong exclusives titles.

VR has been the next big thing for so long that it's easy to be cynical, but this is a huge step. When Microsoft integrates something into Windows, and starts spending serious development money, it's time to take note. The Oculus Rift and HTC Vive have remained niche gaming gear. Microsoft's MR headsets aim to break out of pure VR gaming into wider usage, such as productivity, entertainment, and social media. For example, Microsoft has a new VR social network called AltspaceVR, where your avatar can chat to others.

MR headsets are unlikely to sell in big numbers initially, but prospects look good. Putting all the tracking on the headset is a system others would do well to copy. Software support is decent and will get better, and hardware requirements are OK. VR in Ultra mode is a match for the established systems, and the MR part adds a new dimension, with the potential for some innovative uses. If any VR-style system has a chance to become truly mainstream, this is it. Get the popcorn ready, and watch this space. **–CL**

The first batch of headsets is here, ready to add mixed reality to Win 10. VR has seen many false dawns, could this really be it?

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NEW GOOGLE GEAR REVEALED

Software giant is getting good at hardware, too

GOOGLE HAS an annual hardware event now, cementing its increasing involvement in selling physical gear. This year, it has updated what was already one of the best Android phones: The new Pixel 2 and the larger XL version (now with a 2880x1440 six-inch screen) are not dramatic upgrades to look at, but have a raft of tweaks under the skin. Both have Edge Sense—squeeze the sides and it launches Google Assistant. You also get water resistance, a much-requested improvement. The 3.5mm jack has gone, though there's an adapter in the box. Camera optimization includes optical image stabilization and other trickery to offer what is claimed to be the best image quality on any smartphone. They also sport the latest Android OS. Prices start at $649, and they're already said to be in short supply.

There are two new smart speakers, too. The little Google Home Mini, a $49 pebble akin to the Echo Dot, and the $399 Home Max, a Sonos rival, with decent audio and clever AI to work out volumes and playlists. Then there's the Pixelbook, a sleek aluminum premium Chromebook with a 360-degree hinge. It integrates neatly with the Google family, including Play and Assistant. Undoubtedly funky, but it starts at $999, and reaches a hefty $1,649.

More fun are the Pixel Buds, like Apple's offering, but with Google Assistant built in, and linked to Google Translate. Not quite a Babel fish, but getting close. There's also Google Clips, a small AI-controlled camera that takes images of what it thinks you want—odd at best, creepy at worst.

Google's gear hasn't reached Apple's level of aspirational cool, but it is turning out some decent pieces of hardware. You'll also notice a theme: the integration of Google services into everything. Google is a hardware player, but the core business remains the same, a big bit of which is collecting data on you. **–CL**

YAHOO! HACK WAS ALL THREE BILLION ACCOUNTS

WORST HACK IN HISTORY WAS ACTUALLY A LOT OF WORSE THAN WE THOUGHT

WE KNEW THAT the security breach at Yahoo in 2013 was massive—it was reported that it had lost details on one billion accounts. However, in June, the struggling Yahoo was acquired by Verizon for $4.5 billion, and a new investigation, with the help of outside forensic experts, has shown that Yahoo lost details on all three billion of its accounts.

Yahoo claims that stolen data did not include passwords in plain text (encrypted passwords were stolen then?), payment card, or bank account details. Cold comfort perhaps. What was taken included birth dates, email addresses, telephone numbers, and more. A treasure trove for identity theft. It was the worst cybersecurity failure in history by some margin, and it has taken four years to learn the full extent. The company is sending out emails to "additional affected user accounts." That will be an awful lot of emails. **–CL**

DANGEROUS SEARCH WORDS

McAfee report enumerates the risk

SECURITY OUTFIT McAfee has released a study that examines the most dangerous search terms—those most likely to lead you to malicious sites that aim to steal personal data, install malware, or just bombard you with spurious pop-ups. The average risk rate is 1.7 percent (2 in 125 results are potentially risky), but it can reach over 25 percent if you search for particular things.

Some terms are pretty obvious targets: "free music downloads," "make money," and "game cheats," for example, or anything with the words "free" or "lyrics" in them bring out the hackers. Other dangerous terms are a little harder to fathom: "myspace" and "solitaire." The worst search string? At a risk of 16.1 percent, it is "word unscrambler." Are puzzlers more trusting than most?

Diving deeper into the data and grouping together variations in terms brought out a clear winner: "screensavers." Variations on this brought an average 34.4 percent risk. Another area full of scammers is "working from home"—four times riskier than average. Be wary of searching for "Rihanna," too. Some results are odd, though: "viagra" turns out to be relatively safe, at 0.1 percent. A bit of fun for most perhaps, but some of these numbers are alarmingly high. **–CL**

Tech Triumphs and Tragedies

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TRIUMPHS

✓ **NINTENDO SWITCH A HIT**
Sales of two million a month mean the company is struggling to keep up with demand, and it has yet to launch in China.

✓ **BLACKBERRY RETURNS**
It isn't dead yet—a new keyboardless Android smartphone is being prepped for launch.

✓ **EMOJIS GO GENDERLESS**
Along with iOS 11.1, Apple has introduced new emojis, which now include genderless characters.

TRAGEDIES

✗ **ANDROID WEAR MIA**
Google Store received a refresh, and all the Android Wear gear vanished; development has apparently stalled.

✗ **GOODBYE AOL INSTANT MESSENGER**
The first mass market IM service is terminated; no development and rivals kill the trailblazer.

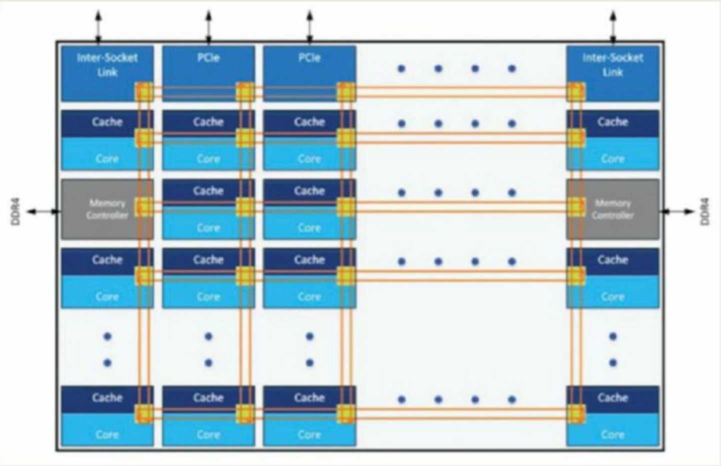
✗ **WINDOWS PHONE IS DEAD**
It'll only receive bug fixes and security updates from now on—lack of apps is blamed.

Jarred Walton

TECH TALK

Making a Mesh of Things

AT THE BEATING HEART of your PC sits the CPU, crunching tasty bits of 0s and 1s in byte-sized chunks. It does so at an extremely fast rate—around four billion cycles per second—but each core can do up to six instructions per cycle, with Skylake-X CPUs containing up to 18 cores. That's 100 billion operations per second (give or take). It's enough to make a math teacher weep with joy.



Skylake-X uses a mesh topology to allow scaling to higher core counts.

Modern CPUs are complex, and the task of routing data between various parts—cache, cores, memory, and I/O controllers—is a critical element of the CPU architecture. For several generations, Intel's HEDT CPUs have used a ring bus architecture.

Think of it as mass transit for data, running in a loop, with stations where data can get on or off. As core counts increase, dual rings are added, with a buffered switch between them. If data needs to move between rings, it's like getting off at a transfer station, and waiting for the next train—a five-cycle delay, on top of the delay from traversing the rings.

The Broadwell HCC (High Core Count) designs supported up to 24 cores, and while it's possible to use additional rings for higher core counts, the increased latency limits scalability. With the Skylake-X HCC/XCC designs (6 to 28 cores), Intel is using a new mesh network. Each block (core, memory, I/O, cache, and so on) has a router, with the blocks in grids. It's like city blocks, with the router switches at each intersection directing traffic. The goal is improved scalability through lower latency.

Despite all the talk of the mesh lowering latency, reducing power use, and improving scalability, in testing it's not all sunshine and roses. Comparing the 10-core Broadwell-E i7-6950X to the 10-core Skylake-X i9-7900X, inter-core communication latencies have increased from 80ns to 100ns. The real-world impact is nowhere near that, though, and higher per-core performance does compensate.

More concerning in my testing of Skylake-X CPUs is that power draw has gone way up from Broadwell-E. At stock, power draw isn't too bad, but all X299 motherboards I've tested auto-overclock. Intel rates the i9-7900X for all-core turbo of 4.0GHz, with a maximum turbo of 4.3GHz (or 4.5GHz via Turbo Boost 3.0 Max), but the base clock is only 3.3GHz.

That base clock is what the CPU is guaranteed to achieve without exceeding TDP, and it's up to the mobo firmware to keep things in check. If power use goes over TDP, clock speeds should drop, but boards are being more aggressive. Some run all cores on the i9-7900X at 4.0GHz, no matter what, and others default to 4.3GHz and even 4.5GHz. Power use scales rapidly, but the real problems start to show up on the i9-7960X and i9-7980XE.

The TDP is 165W for both, and they went well over that. System power use in Cinebench R15 is around 350W, with 50-100W going to other components, so the CPUs use over 200W. Push clock speeds to 4.0-4.4GHz on all cores, and it goes to over 500W. Overclocker der8auer took things to the next level with liquid nitrogen on the i9-6980XE, and got all 18 cores to 6.1GHz—using over 1,000W just for the CPU.

These are amazingly fast CPUs, but we're hitting the limits of 14nm. Mesh topology may pave the way for more cores, but even though it has two fewer cores, the i9-7960X is only 3-5 percent slower than the i9-7980XE. If Intel made a 24-core CPU, without 10nm it's unlikely to deliver a significant boost in performance without an equivalent increase in power use. Moore's Law is dead, right when we need it most.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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Alex Campbell

OPEN SOURCE

For Goodness' Sake, Apply Your System Updates

WE (SHOULD) ALL KNOW BY NOW that system updates are important. If you don't keep your system updated, your data could be compromised. And that sucks for you. When an enterprise doesn't run a system update, it can compromise millions of people's data. That sucks for everybody.

It happened again: There's been another breach of security that leaves the personal information and Social Security numbers of US citizens exposed. I've seen this once before with the Office of Personnel Management hack a couple years ago. This time, however, the scale of the breach dwarfs all others. I also noticed that the affected organization was using open-source software. What?

One thing open-source and Linux users like to say is that the OS and software is more secure than proprietary software. This is true for one big reason: A volunteer programmer is free to experiment and contribute any code in order to fix bugs or add new features. Any open-source code that is found to have a vulnerability can be fixed by anyone with the interest and skill to do so. Generally speaking, security holes are fixed as soon as they are found. When the SambaCry vulnerability was discovered, patches were available within a day or two.

There are downsides, though. Vulnerabilities (also called "vulns") can be reported in public mailing lists or bug trackers. While it's great for developers to have easy access to the information they need to patch the code, it also makes the vuln public knowledge. Furthermore, patch notes often have details about what type of vulnerability the patch fixes. At that point, running unpatched software is like living in an old circular saw blade warehouse that's been marked seismically unsafe in a city such as Tokyo or San Francisco. When something goes wrong, you can't say someone didn't warn you.

> There is a legitimate fear that a botnet of smart LED light bulbs could bring down critical infrastructure.

As for the Equifax hack, a vuln in Apache Struts (CVE-2017-5638) was posted by the National Institute of Standards and Technology (NIST) on March 10. (The notice describes a vulnerability that would allow a remote attacker to upload a file and execute arbitrary code.) The Struts team released a patch that mitigated CVE-2017-5638 on March 7. Equifax issued a statement on September 7 saying it detected an intrusion as early as May. I'll let you do the math.

Besides a sudden interest in how credit freezes work, what you should take away from this as an end user is that updating software matters. After all, Equifax isn't alone. There are countless blogs running old versions of WordPress or WordPress plugins that are compromised every day. There's also a lot of angst about the Internet of Things: Many IoT devices don't have an update mechanism for users to keep those devices patched. There's a legitimate fear that a botnet of smart LED bulbs could bring down critical infrastructure.

Sure, we love to moan about Windows 10 updates, but they keep you safe. Likewise, running Linux without regular updates only offers a false sense of security. Running updates manually one per week is a good habit to get into. And since running an update often only takes one or two console commands, it's not exactly a burden. If you're running programs compiled from source, be aware that your package manager won't update those programs, and updates are your responsibility. If you're running an Internet-facing web server or NAS at home, keeping your systems updated is even more crucial.

STRUTS
Apache Struts
Download
Technology Primer

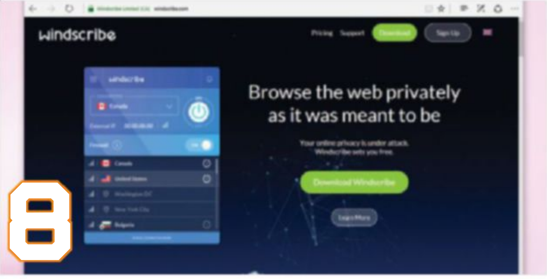
It is believed Equifax was using an outdated version of Apache Struts.

When you do find yourself updating your system, remember that any of the programs listed in the update, left unpatched, could be a potential weak point; it only takes one application to compromise a system. With the growing complexity of computer systems, there will always be security holes. But if you update your system regularly, you can plug those holes as soon as they become apparent.

Alex Campbell is a Linux geek who enjoys learning about computer security.

THE LIST

TOP FREE VPNS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Browse the web privately as it was meant to be

8

WINDSCRIBE 10GB of free traffic per month is nothing to sniff at, and it runs as a browser plugin, too.

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Simple, private, free access to the open Internet you ♡

7

TUNNELBEAR A big name with a big ad budget, but only 500MB free per month (without a promo code).

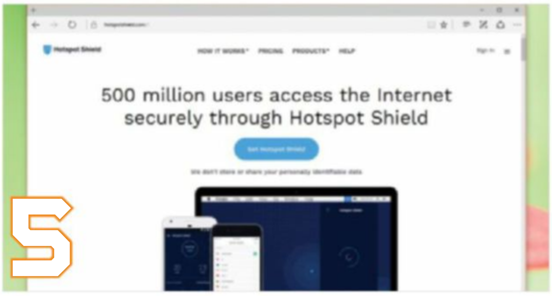
PrivateTunnel

Your Privacy • Your Security

Take Control

6

PRIVATETUNNEL 200MB of free traffic; cheap data bundles (or a $30 subscription) cover the rest.


Hotspot Shield

500 million users access the Internet securely through Hotspot Shield

5

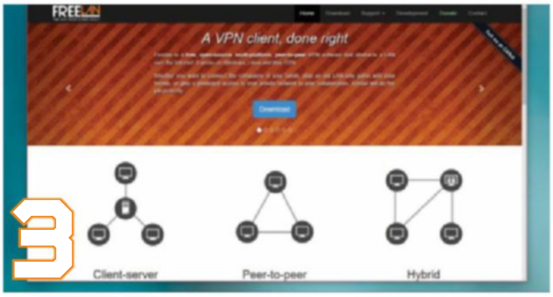
HOTSPOT SHIELD Ad-supported way to get 750MB per day anonymized, though locales beyond US cost you.

Speedify
Download Speedify
What is a VPN?

Speedify makes the Internet more secure

4

SPEEDIFY Cleverly combine, say, LTE and Wi-Fi for a faster connection, with encrypted logless traffic, too.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Peer-to-peer
Hybrid

3

FREELAN A DIY solution for client/server, peer-to-peer, or even hybrid VPNs between your own machines.

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VPN Service
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Your private path to access network resources and services securely

2

OPENVPN Support packages cost you—and it can be outrageously complex—but OpenVPN is used by the pros.

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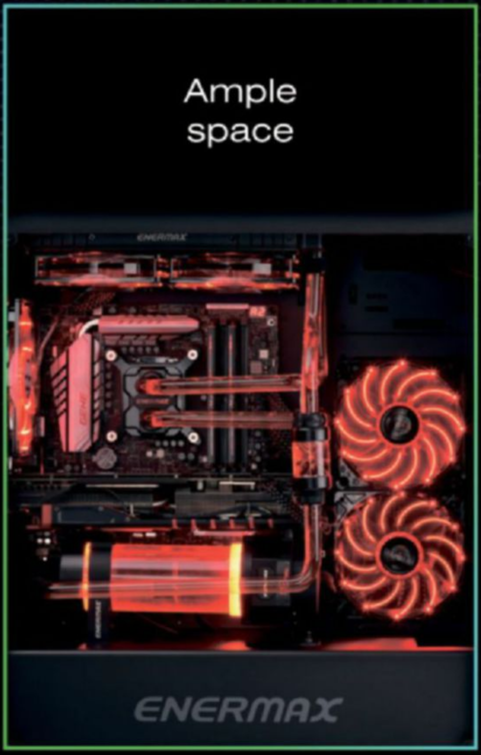
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HEAD TO

BY **ALEX COX**

Best Sites for Game Streaming

Twitch was once the dominant force in streaming, but that's not necessarily the case today—like any large online entity worth its salt, it's being chased by a host of competitors. While we could have considered the likes of hitbox.tv, gaminglive.tv, and their ilk, streaming only has a value if it has an audience, so we've bashed the big three against each other: Twitch, YouTube Live, and Microsoft's Mixer, which is baked in to Windows 10, post Creators Update.

ROUND 1

Quality

Your stream quality is going to depend hugely upon the stability and capacity of your broadband connection. Even faster pipes are often weighted heavily toward downloading rather than upload speed, so the broadcast quality you get out of any of these services is rather subjective. Streaming hosts generally ask you not to compensate for lagging with a variable bitrate stream, because this causes massive problems for some viewers, and higher bitrates mean that most viewers are forced to switch to a lower-quality transcoded stream.

If you happen to be able to fling packets at the Internet with limitless abandon, your selection of streaming service will, as ours does, come down to the maximum bitrate supported. Twitch offers a soft limit, so you can send whatever bitrate you like, but it would prefer you to keep your stream under 3,500kb/s, and it warns streamers who exceed this mark. YouTube Live, which transcodes every stream sent to it, can accept just about anything, but higher bitrates are squashed by its compression algorithm. Microsoft's Mixer supports a maximum of 10,000kb/s without moaning, by which point your router will be on fire anyway.

Winner:
Mixer

ROUND 2

Tools

Much of the streamer's toolbox consists of third-party tools such as XSplit, OBS, or Gameshow. The former pair happily support all three services on test here, while Gameshow only supports Twitch and YouTube at this time. But preparing your stream is only one part of the DIY puzzle; working with it is quite another.

Twitch's back end is well seasoned and, while sometimes complex, has been built with its huge community of users in mind. The Twitch Dashboard is super-handy to have open while you're streaming, giving you an at-a-glance overview of chat, your stream quality, and much more, and there are services in there to test the stability of your connection and how it relates to Twitch's standards.

YouTube Live's online controls are, like those of its standard service, a little haphazard. There's plenty of fine operational control on offer, but some questionable design decisions mean its dashboard doesn't easily fit everything above the fold in your browser, something of an oversight, considering your hands will likely be on the controls. And then there's Mixer, which presently offers a rather simple interface. Good for beginners, but control is important.

Winner:
Twitch

ROUND 3

Audience

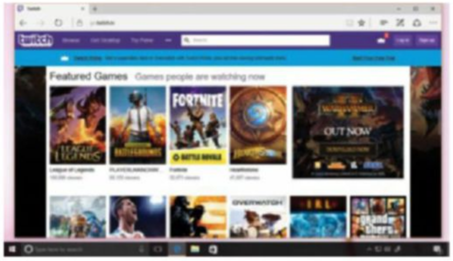
If eyes on your content is your concern, you'd be wise to question whether Mixer is the right platform for you with its present userbase. Microsoft hasn't announced any concrete numbers for the fledgling service, which had only been around for six months before Redmond snatched it up, but even its top channels don't exceed more than a few hundred viewers.

You'd imagine that YouTube, the most popular video service in the world, would mean big numbers for streams, but that's still not necessarily true. Users with an existing name and reputation can attract a hefty viewership, it's true, but YouTube's live offering is still finding its feet, and realistically you'll need to attract subscribers before anyone will stumble on your live output.

Twitch's growth has slowed due to increasing competition, but it certainly hasn't reversed. Its top streams (admittedly, these are large esports events) have broken a million concurrent viewers, and even the top solo streamers have been able to attract a quarter of a million eyes. It's also a lot easier to discover new streamers on Twitch, and its users will habitually search by game—a handy driver.

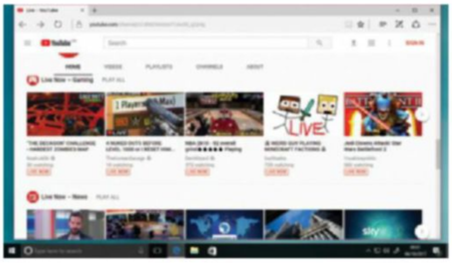
Winner:
Twitch

HEAD



Twitch, borne of Justin.tv and now part of Amazon, is the home of big-numbers streams.

Microsoft Mixer's Channel One aids in the discovery of streams.



YouTube Live's gaming category tends to be rather on the quiet side.

ROUND 4

Monetary Gain

When—sorry, if—your profile blows up, there's a lot to gain from streaming. A lucky few are even able to ditch the day job and play games for a living. This funding could come through private donations, via Patreon, or it might be by taking advantage of one of the services' partner programs.

Twitch leads the way here. Hit one milestone—50 followers and proof of regular streaming—and your viewers can subscribe to your channel, chipping in a little each month (shared with Twitch) to receive additional benefits. Cement your status, and you can become a Twitch partner, which offers a host of extra goodies, such as control of (and a slice of the profits from) mid-roll ads. Twitch viewers can also earn Bits, a local currency with which they can tip their favorite streamers.

Mixer's subscription program is relatively young and, given its current viewership, not yet particularly profitable, although you can apply to jump to Mixer if you're already established elsewhere. YouTube Live offers Super Chat, where viewers can pay to highlight their messages, as well as a share of ad revenue, and in some cases, sponsorship opportunities.

**Winner:
Twitch**

ROUND 5

Extra Tech

One streaming service is much like the other, right? Not so. Stream delay can be a benefit if you're a big player, and Twitch's revised stream delay is perfectly acceptable. Users at partner level can go the other way, and add up to 15 minutes of lag to their streams to prevent games of *PlayerUnknown's Battlegrounds* becoming a festival of honking horns and incessant trolling. YouTube does offer latency options, although nothing so extreme, and its ultra-low setting can lead to some fairly ropey output. If you really want to go near-instant, Mixer's FTL streaming can take advantage of higher bitrates for direct streaming to viewers with virtually no lag—perfect for an interactive stream.

We should also point out integrations at this point. If you're not concerned about presentation, or plastering your webcam and a bunch of other stuff on top of your stream, Mixer's integration with the Windows Game Bar (and, indeed, with the Xbox One) make it a great choice for fire-and-forget streaming to a bunch of your buds. While Twitch also has its claws in the major consoles, there's nothing more simple on the PC than Mixer.

**Winner:
Mixer**

And the Winner Is…

We've surprised ourselves here. Mixer's win on two key criteria is, frankly, not the result we were expecting, coming in to this head-to-head, and it's a bit of a skewed result, given the importance of the audience metric. In truth, we'd never actively lean toward Mixer if we were looking to create a growth stream. YouTube Live's relative lack of success is also something of a shock, although as it continues to grow, and its discovery features (and its viewers' tendency to use them) expand, it'll surely become more of a viable option: There's no stopping the machine.

In all, though, Twitch is far and away the platform to choose for beginners and experts alike. It is the home of gaming streams. Some of its policies seem archaic and restrictive, but if you can work within its guidelines, and present a quality product, Twitch gives you every opportunity to take your livestreaming to the next level, and perhaps even earn a little spending money to boot. Ask us in a couple of years, though, and the answer could well be different….

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Storage Ceilings
> Office Work
> Memory Bandwidth

Storage Limits

Hi Doc, I have a Plex media server on a Windows 10 system, using storage spaces for the media files. I was using five 4TB hard drives in RAID with parity, but decided to upgrade the drives one at a time, so purchased a new 8TB disk, removed one of the older, smaller HDDs, and installed the larger repository.

When I went to increase the size of the storage spaces, I received an error saying they could not be extended, because the number of clusters would exceed the maximum supported by the filesystem. Apparently, I defaulted to a 4KB cluster size, and now my storage spaces are gimped to 16TB. Is there any way to increase the cluster size without wiping everything and reformatting each disk? **–Jon Preu**

THE DOCTOR RESPONDS: What you're running up against is a limitation of Microsoft's proprietary New Technology File System, which keeps volumes constrained to 2^32-1 clusters. Multiplying that out by a 4KB cluster size gives you your 16TB ceiling. Jumping to, say, 64KB clusters (the largest allowed by NTFS) increases the maximum to 256TB, yielding plenty of headroom for expansion in the future.

This means the smallest unit of disk space allocation grows to 16x the existing 4KB clusters, so available capacity is utilized less efficiently. For instance, a 65KB file would normally span 17 4KB clusters, wasting 3KB on the last one. The same file eats up 128KB across two 64KB clusters, 63KB of which goes unused. On a server hosting lots of little files, big clusters are more of an issue. Fortunately, media servers typically host large files, minimizing the impact of this inefficiency.

The Doc has mentioned MiniTool's Partition Wizard before; the free version is very useful as a supplement to Microsoft's Disk Management console. Upgrading to the Professional version for $39 unlocks a feature to change cluster sizes without data loss. Acronis Disk Director offers similar functionality for $50. If you're already running backups (and verifying them), there's always the option to wipe the previous volume and re-format with larger clusters before restoring your media files.

Asus's Transformer Book T102HA offers strong specs, yet is quite cheap.

Sudden Shutdowns

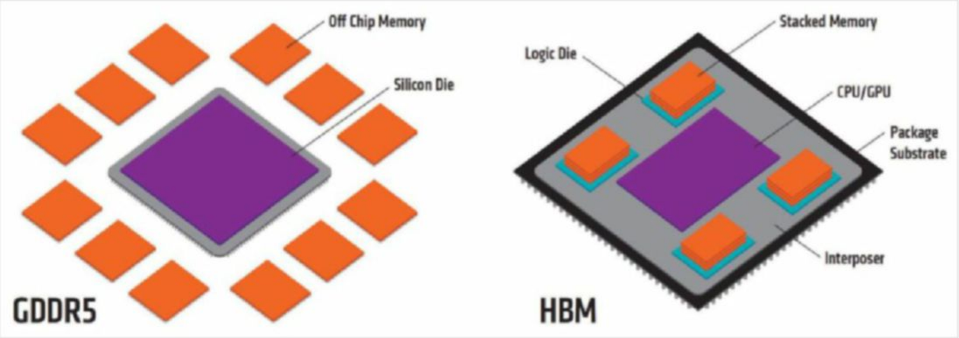
Dear Doctor, I have an Asus Transformer Book T100TAM running Windows 10 that has a 500GB hard drive. It shuts off automatically after being on for 29 minutes and 39 seconds. It does this whether I plug into an AC socket or run on battery power. I checked all the Windows power settings I am aware of, and found nothing that might be triggering shutdowns. I read a number of online forums as well, and noticed others with a similar problem. To determine whether my issue is caused by hardware or software, I even tried booting into Linux from a USB thumb drive (which didn't work). This doesn't appear to be a problem caused by high temperatures, because there is no fan to begin with. Please help! **–Calvin**

THE DOCTOR RESPONDS: The 30-minute shutdown issue pops up intermittently across the web, and doesn't seem limited to one specific PC make or model. What most of the threads with solutions have in common, though, is motherboard work—most suggesting a replacement.

Boot up your Transformer Book, enter the BIOS, and let it sit. If it shuts down right when you'd expect, Windows isn't the culprit. Make sure you're running the latest firmware (build 400, released on 5/19/2016), even if it doesn't sound like updates fix this issue for most people reporting it.

You may be able to pick up a used T100TAM for cheap on

↘ submit your questions to: doctor@maximumpc.com



HBM2 helps AMD save space on its Vega-based cards, while matching the bandwidth of GTX 1080 Ti.

eBay if all else fails. Then again, given the newer T102HA's faster Atom x5 CPU, doubled RAM, and improved wireless networking, that might be a better option for less than $300.

Microsoft Office Issues

Doc, I have a long-standing issue with Microsoft Office 2010 32-bit (on a system running Win 10 Pro 64-bit). I've exhausted every avenue for getting help from Microsoft, including its nightmare of a public support forum.

When I double-click any Office file, I get a message that the software is installing Microsoft Office Single Image instead of just opening the corresponding program. But if I open Word, say, through a shortcut I make to the app, the message doesn't appear. I need help understanding the difference between double-clicking a file and opening the same file with Word, or any other Office app, already open.

Office 2010 is currently the only software on this machine, although I've installed and uninstalled previous versions along the way as I upgraded.
–Ken St. John

THE DOCTOR RESPONDS: For some reason, Office files are pointing to the binary OEMs used for deploying the various versions of Office 2010. And as you've experienced, searching for answers can be an exercise in frustration with such a large and complex suite of apps.

Providing you have the means to re-install your copy of Office, it may be best to completely uninstall it and start afresh. Check out https://goo.gl/NY4Kdm for instructions to manually eradicate every bit of the suite from your system.

Understanding GPUs

Doc, I'm trying understand how memory bandwidth on GPUs works by comparing the Zotac GeForce GTX 1080 Ti AMP Extreme and MSI Radeon RX Vega 64. Correct me if I am wrong, but the GTX 1080 Ti offers bandwidth of 1Gb/s per pin, while the Vega 64 boasts 2Gb/s per pin (Pascal versus HBM2). Respectively, they include 11GB of GDDR5 and 8GB of HBM2.

What does the difference in memory bandwidth per pin mean for performance? Is there a use for the higher bandwidth that would allow AMD's card to outperform the 1080 Ti? Is the difference irrelevant when we consider that the Zotac board only costs $100 more? **–Kevin G**

THE DOCTOR RESPONDS: Memory bandwidth is a function of memory technology, clock rate, and bus width. Although HBM employs very wide busses, it also operates at much lower frequencies than GDDR5X. So, in the case of GeForce GTX 1080 Ti versus Radeon RX Vega 64, you're looking at dissimilar architectures.

On the GTX 1080 Ti, Nvidia enables 11 of the GP102 processor's 12 available 32-bit memory controllers, yielding an aggregate 352-bit bus. Each controller hosts 1GB of GDDR5X operating at 11Gb/s. Take 352 bits, divide by eight to turn the number into bytes, then multiply by the memory's transfer rate: you get 484GB/s of peak bandwidth.

On the Vega 64, AMD uses two stacks of HBM2, facilitating a 2,048-bit bus. Each stack adds 4GB, which is how the card gets its 8GB total. Compared to the GTX 1080 Ti's 11Gb/s GDDR5X, though, Vega 64's HBM2 runs at 1.89Gb/s. When you plug those numbers into the same equation, AMD's theoretical bandwidth matches Nvidia.

As we've already seen in the benchmarks, the Radeon RX Vega 64 performs more like the GeForce GTX 1080 than the higher-end 1080 Ti, so gaming performance in this case isn't defined by a memory bandwidth bottleneck, but by other architectural trade-offs that AMD made to give Vega workstation/compute appeal.

Electronic Snail Mail

Hi Doc, do you know any services that allow you to send snail mail printouts from the web, similar to those postcard-from-photo services? I know there is FlyDoc from Esker.com, but it requires a minimum $100 fee upfront. **–Tatyana Shmeleva**

THE DOC RESPONDS: If you're looking for a low-volume alternative to FlyDoc, check out LetterStream, Docsaway, and Mail A Letter. Between them, sending a basic one-page, one-sided letter starts under $1, and quickly gets more expensive if you need tracking, Certified Mail, or Registered Mail to other countries. Options abound for double-sided printing, return envelopes, postcards, and even check/payment printing.

Ripping CDs in 2017

Hi Doc, I am a long-time reader of *Maximum PC*, and I'd like to follow up on a couple of questions about ripping audio CDs that were asked in previous issues.

In the "Ultimate Guide to Digital Media" from May 2011, you mention that if you want to ensure ripped CDs are 100 percent error-free, use AccurateRip, Exact Audio Copy, or dBpoweramp Reference. Does the Doc still think that those represent the best way to rip a collection of over 200 newly acquired CDs?

From "Rip Archival-Quality MP3s from Audio CDs" back in the Holiday 2009 issue, you mention Lame and EAC. Again, are they still the best for archival-quality MP3s?

Lastly, if a hacker gained access to a machine protected by BitLocker, wouldn't the system's information be useless because it was encrypted? **–Marvin Malasky**

THE DOCTOR RESPONDS: The recommendations you cite are still good today, Marvin. Exact Audio Copy is regarded as perhaps the best free CD ripper, while dBpoweramp is top-shelf as far as paid software goes (a single-PC license sells for $39). Both take advantage of AccurateRip's technology for verifying the perfection of ripped tracks against an online database.

If your BitLocker-enabled PC is compromised by a hacker, its contents are not protected while Windows is running. The feature safeguards against offline attacks. In the event that your hard drive is removed and attached to another machine for the purpose of reading its data, 128/256-bit encryption makes the disk unreadable. But if someone sneaks off with your notebook or connects to your desktop over a network, BitLocker won't help. Strong passwords, strict permissions, and some common sense are your best defenses against unauthorized guests. ⏻

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- Opt. NVIDIA® GeForce™ GTX 1060 or 1080 GPU
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- Optional NVIDIA® GeForce™ GTX 1070 GPU
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- NVIDIA® GeForce™ GTX 1070 8GB GPU
- 16GB DDR4-2400MHz Memory
- 256GB WD Black NVMe M.2 SSD + 1TB 5400RPM Hard Drive
- Full Color Programmable backlight Keyboard
- Intel® Dual Band Wireless-AC 8265 + Bluetooth
- Thunderbolt Gen3 & USB 3.1 Type-C Port
- Sound BlasterX Pro-Gaming 720° Sound System
- Slim design with only 0.98 inches thin

NP8952 Notebook

$1,699

After $100 Instant Savings

- Windows 10 Home
- 7th Generation Intel® Core™ i7-7700HQ Processor
- 15.6" Full HD IPS Matte Display (1920x1080)
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- NVIDIA® GeForce™ GTX 1070 8GB GPU with Max-Q design
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- Built-in 2.0M FHD Camera & Fingerprint Reader
- **Ultra-slim design with only 0.73 inches thin**

NP8157 Notebook

$1,699

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- Windows 10 Home
- 7th Generation Intel® Core™ i7-7700HQ Processor
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- 15.6" Full HD IPS Matte Display (1920x1080) w/NVIDIA® G-SYNC Technology
- Opt. 15.6" 4K QFHD or FHD 120Hz 5ms, Matte Display with G-SYNC
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- 16GB Dual Channel DDR4-2400MHz Memory
- 250GB WD Blue M.2 SSD + 1TB 5400RPM Hard Drive
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- Headphone output w/ESS SABRE HIFI Audio DAC

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- NVIDIA® GeForce™ GTX 1060 6GB GPU
- 16GB DDR4-2400MHz Memory
- 256GB WD Black NVMe M.2 SSD + 1TB 5400RPM Hard Drive
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$1,099

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- 8GB DDR4-2400MHz Memory
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- Sound Blaster® Cinema 3 Sound System

NP6852 Notebook

$949

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TODAY'S BEST UPGRADES

Bring your system bang up to date with some choice hardware picks

BY MAXIMUM PC STAFF

UPGRADING IS FUNDAMENTAL to the PC. It's one of the cornerstones of our platform of choice, and it's why the PC has survived while other systems have failed. It's also the reason why you can focus on the hardware that matters the most, and spend your money appropriately. You can upgrade in stages—if you want to focus on a performance CPU first, with a mind to upgrading your graphics card or storage later, you can. As long as you know what's happening in the tech world, you're in good shape.

On that note, we've just had an incredible year for processors. AMD has come out swinging with its Ryzen line, with increased core counts and strong raw performance. And Intel has just responded with its eighth-generation CPU line—we've managed to squeeze the first chips to arrive into our recommendations, too. Which means we're now looking at two completely new mainstream platforms that didn't exist a year ago. Plenty of opportunities for upgrades, in other words.

Bear in mind that any new piece of gear should have a legitimate upgrade path as well. Getting the best processor for your motherboard is fine, but it takes the shine off it a bit if you know there's a whole new platform doing the rounds. That's why our recommendations all relate to the latest hardware lines. This shouldn't stop you upgrading older hardware as far as it can go, though, because that can often be a cost-effective route—especially if you're happy to take the risk of buying used hardware (great for older processor deals, and making the move to SLI).

Over the page, we look at the best hardware upgrades you can buy right now, with performance benchmarks where they matter. We cover all the major components, and highlight things to watch out for when upgrading. It's a great time to give your machine a new lease of life, as you're about to find out.

NVIDIA
RYZEN
crucial
BALLISTIX SPORT DDR4
SAMSUNG
NVMe SSD 960 PRO
512GB

Price Range Color Key

MAXIMUM PC High-end
MAXIMUM PC Mid-range
MAXIMUM PC Budget

PROCESSORS

AMD Ryzen Threadripper 1950X

$999

www.amd.com

High-end
AMD RYZEN THREADRIPPER

THERE IS AN ARGUMENT for going with Intel's Core i9-7980XE for your high-end upgrade: It's an absolute beast, with its 18 cores and 36 threads. It does cost $2,000, though. For the vast majority of us, such a move makes no sense. If you want high-end performance that will leave your bank balance vaguely intact, Threadripper is the way to go. And at $999, the 16-core 1950X is the best that AMD has on offer. Yup—half the price for two fewer cores (four threads).

The AMD Ryzen Threadripper 1950X is an incredible slice of silicon, effectively squeezing a pair of Ryzen 1800Xs into one package. There are big wins in addition to the phenomenal core count, too, including 64 PCIe lanes, support for quad-channel DDR4, and 40MB of L3 cache. This is a serious chip that will relish high-end, multithreaded applications. It happily turbos up to 4GHz, and stays cool while doing so; 60 C puts Intel's latest to shame.

The resultant chip is physically huge, so AMD has introduced a whole new package and mounting mechanism—it's an interesting system that helps ensure you don't damage your new motherboard or expensive CPU when installing it. Speaking of which, you will, of course, need a new motherboard to go along with your top-end chip, and we cover our recommendation for X399 on page 34.

Intel Core i5-8400 $190

www.intel.com

AT LAST, WE'VE SEEN it come to fruition. Intel has finally thrown off the shackles of those four-core limitations, and added an additional two cores to the vast majority of chips in its arsenal of mainstream processors. It is, in essence, an effective way of combatting AMD's Ryzen eight-core parts, without having to redevelop an entire architecture to do so.

The Core i5-8400 is the absolute sweet spot in the lineup, and for those looking for a mid-range, no fuss chip, that gets the job done, it's the new king of the hill. Although it still lacks the Hyper-Threading of its Core i7 superior, the inclusion of those two Coffee Lake cores on top of the usual four provides a raft of additional processing prowess, capable of demolishing the older Core i7-7700K. It is, by far, the best value processor you can buy to date, coming in at a faintly ridiculous $190.

That's not to say there aren't any limitations with Coffee Lake, the big one being temperature. Intel is still refusing to invest in any form of decent thermal interface material between the die and the IHS, and because of that, temperatures are toasty, even on this locked Core i5. Plus, although the socket may be the same, there's no backward compatibility at all, meaning you'll be investing in a new motherboard as well.

AMD Ryzen 3 1300X $130

www.amd.com

AS AN UPGRADE, a budget chip is a tricky concept. We've been recommending the Intel Pentium G4600 for our budget build for the best part of a year, but when it comes to an upgrade, we can't really recommend a last-gen CPU that slots into a last-gen motherboard. So instead of tying ourselves in knots trying to predict which platform you're upgrading from, we've picked a chip that offers strong performance at a great price point. The Ryzen 3 1300X may not have the headline-grabbing thread count of the top-of-the-range 1800X, but this is still an unlocked quad-core chip for not much cash.

Talking of cost, you'll need to buy an AM4 motherboard to use it, and possibly some DDR4 memory to go with it, if your current system is a little long in the tooth. So that $130 price tag isn't the whole story, but this is still a good value proposition, with a decent upgrade path of its own, which is always worth considering at the budget end of the scale. The retail chip comes with the Wraith cooler as well, which does a fine job of keeping it cool while hitting the 3.7GHz turbo, so no immediate need to grab a separate all-in-one to get the most from this chip.

PROCESSOR BENCHMARKS

Chip	Cores/ Threads	X265	Cinebench R15 Single	Cinebench R15 Multi	Fry Render	Power Draw Idle	Power Draw Load	Total War: Attila	Far Cry Primal	Price
Intel Core i9-7980XE	18/36	41.12	184	3,331	64	66	258	41	77	$2,000
AMD Ryzen Threadripper 1950X	16/32	38.29	167	3,012	84	91	271	35	75	$999
Intel Core i9-7900X	10/20	38.15	180	2,218	94	86	223	41	77	$970
AMD Ryzen Threadripper 1920X	12/24	35.39	152	2,308	127	67	243	37	75	$800
Intel Core i7-7820X	8/16	30.45	194	1,741	122	83	197	40	76	$600
AMD Ryzen 7 1800X	8/16	27.89	159	1,612	161	56	182	39	75	$450
Intel Core i7-8700K	6/12	30.65	205	1,553	133	65	198	41	77	$380
AMD Ryzen 7 1700X	8/16	26.81	154	1,542	172	57	143	39	74	$360
Intel Core i7-7700K	4/8	20.68	194	970	225	44	110	41	77	$310
AMD Ryzen 7 1700	8/16	24.12	147	1,406	178	47	115	35	73	$300
AMD Ryzen 5 1600X	6/12	22.18	159	1,223	226	45	115	36	74	$240
Intel Core i5-7600K	4/4	15.86	179	663	346	44	103	40	77	$220
Intel Core i5-8400	6/6	22.24	172	956	231	44	123	41	77	$190
AMD Ryzen 5 1500X	4/8	15.85	154	807	329	42	101	36	75	$179
AMD Ryzen 5 1400	4/8	13.61	131	693	380	55	93	33	71	$165
AMD Ryzen 3 1300X	4/4	12.64	139	550	462	56	95	36	73	$130

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GRAPHICS CARDS

Nvidia GTX 1080 Ti

$710 www.nvidia.com

High-end
GTX 1080 Ti
NVIDIA

GRAPHICS CARDS ARE in a bit of an odd state right now. For the last 18 months, Nvidia has been left unchallenged, with AMD only providing any hint of competition in the mid-range. The RX 500 refresh was little more than a badge swap, and Vega a dud—a disappointing high-end solution, overhyped to its own detriment (although it struts its stuff nicely when it comes to cryptocurrency mining, annoyingly).

So, how does the land lie if you're looking to invest in a high-end GPU? How do you power a 4K gaming rig in today's market? Well, fortunately, Nvidia hasn't been resting on its laurels, and is still focused on trying to capture as much of that market share as it can. At the start of this year, it dropped the bombshell that is the GeForce GTX 1080 Ti, and hasn't really looked back.

Think of it as a cut-down Titan Xp, a warhorse of a GPU focused solely on gaming, but coming in at a far more attractive price point. The differences are slim, with its 1GB of GDDR5X being one of the few things cut from the titanic juggernaut. The Titan Xp is ever so slightly more powerful—about 15 percent or so—but it also costs $500 more, making it a superfluous product aimed

MSI GTX 1070 Gaming X 8G

$440 www.msi.com

OH, HOW mid-range has changed over the last few years. Once upon a time, the card to have for anyone wanting a fairly healthy PC was the GTX 660 Ti. It was cost-effective, powerful for its day, and clocked like a champ. However, as the battle lines widen, and GPU prices extend ever upward, our idea of what a mid-range card actually includes has inevitably increased, too.

It isn't all bad, however, because central processing prowess becomes ever more affordable—offsetting the GPU price with a cheap CPU balances the books, while providing higher frame per second solutions for the same amount of green.

The GTX 1070 is a prime example of this. With performance matching the height of Maxwell's frame-rendering capabilities, it's a card that makes the once-premium 9 series Titan X affordable, cutting the price by 66 percent. MSI's Gaming X variant provides an exceptionally fine balance between noise reduction and thermal management. There's no superfluous RGB lighting here, and the only hint of any "gaming" heritage lies in the small red accents located under the card. Couple that with a powerful stack of 8GB GDDR5X and its bunker-busting Pascal GPU, and the GTX 1070 dominates 1440p with ease, providing average frame rates well into the 60fps range that every enthusiast with a gaming habit covets.

GRAPHICS CARD BENCHMARKS

High-End 4K GPUs (Over $550)

Nvidia Titan Xp
Nvidia GTX 1080 Ti Reference
AMD Radeon RX Vega 64
PNY GTX 1080 XLR8 OC
Asus ROG Strix GTX 1080

Our test bed consists of an Intel Core i7-7700K, 16GB

Mid-Range 1440p GPUs ($300–$550)

AMD Radeon RX Vega 56
Nvidia GTX 1080 Reference
MSI GTX 1070 Gaming X 8G
Nvidia GTX 1070 Reference
Sapphire Radeon RX 580 8GB

Our test bed consists of an Intel Core i7-7700K, 16GB

Budget 1080p GPUs ($120–$300)

Gigabyte Aorus RX 570 4GB
Zotac GTX 1060 AMP Edition
EVGA GTX 1060 3GB SC Gaming
Asus ROG Strix GTX 1050 Ti 4GB
EVGA GTX 1050 Ti SC Gaming 4GB

Our test bed consists of an Intel Core i7-7700K, 16GB

solely at the affluent, or those who need the Titan's very specific developer skill set, as limited as it is.

EVGA GTX 1060 3GB SC Gaming

$226

www.evga.com

SO, WHERE IS AMD in all of this? The sad reality is that AMD isn't providing any competitive solutions at any of the right price points. Vega's lack of availability and sub-par performance has left the upper echelons empty, while the mid-range and budget solutions suffer from cryptocurrency fever. Unless you absolutely cannot live without FreeSync, there is no justifiable reason to run with an AMD card, either as an upgrade or in a fresh build.

At the budget end, there's only one choice: the GTX 1060 3GB. We've recommended it all year, and for good reason: It's at the price and performance sweet spot, even up against Nvidia's own GTX 1050 Ti. Look at the figures—for $40 more, you get a card that's 50 percent faster than the next step down, gives the GTX 980 a run for its money, and masticates 1080p. Because Nvidia's GTX 1050 Ti is so unattractive, seemingly nothing more than a die shrink, and spec for spec almost identical to the 950, the 1060 3GB is incredibly appealing.

VRAM	Total War: Attila	Far Cry Primal	The Division	Rise of the Tomb Raider	Power Draw Idle	Power Draw Load	3DMark: Fire Strike Ultra (DX11)	3DMark: Time Spy (DX12)	Price
12GB GDDR5X	16/29	54/62	35/61	12/32	49	365	7,166	9,097	$1,200
11GB GDDR5X	14/27	51/56	39/55	11/29	47	354	6,587	8,307	$710
8GB HBM 2.0	9/16	36/43	22/43	13/20	66	403	5,241	6,758	$620
8GB GDDR5X	9/19	39/43	26/41	8/20	53	334	5,077	6,597	$580
8GB GDDR5X	9/20	40/44	21/43	8/22	49	325	5,339	6,892	$570

of Corsair DDR4, an Asus Maximus IX Hero, and a 500GB Samsung 850 Evo. All games tested on the highest graphical profile, with AA at 4K, minimum and average frame rates recorded.

VRAM	Total War: Attila	Far Cry Primal	The Division	Rise of the Tomb Raider	Power Draw Idle	Power Draw Load	3DMark: Fire Strike Ultra (DX11)	3DMark: Time Spy (DX12)	Price
8GB HBM 2.0	21/31	58/69	42/67	22/36	64	331	8,656	6,263	$520
8GB GDDR5X	23/40	65/77	39/73	16/42	48	252	9,371	6,537	$510
8GB GDDR5	23/36	55/65	47/63	14/35	53	306	8,221	5,753	$440
8GB GDDR5	21/34	53/62	34/59	13/33	47	288	7,805	5,542	$410
8GB GDDR5	19/25	40/48	25/49	11/26	59	297	6,033	4,515	$370

of Corsair DDR4, an Asus Maximus IX Hero, and a 500GB Samsung 850 Evo. All games tested on the highest graphical profile, with AA at 1440p, minimum and average frame rates recorded.

VRAM	Total War: Attila	Far Cry Primal	The Division	Rise of the Tomb Raider	Power Draw Idle	Power Draw Load	3DMark: Fire Strike Ultra (DX11)	3DMark: Time Spy (DX12)	Price
4GB GDDR5	24/31	45/56	32/56	7/33	66	268	10,243	3,833	$270
6GB GDDR5	26/38	53/66	31/60	15/38	53	225	10,959	4,158	$270
3GB GDDR5	24/36	49/61	31/55	9/35	47	251	20,251	3,905	$200
4GB GDDR5	14/23	34/43	19/36	9/23	52	216	7,042	3,209	$180
4GB GDDR5	13/22	32/40	17/36	9/23	43	201	7,012	3,188	$155

of Corsair DDR4, an Asus Maximus IX Hero, and a 500GB Samsung 850 Evo. All games tested on the highest graphical profile, with AA at 1080p, minimum and average frame rates recorded.

MOTHERBOARDS

Asus Prime X399

$350 **www.asus.com**

High-end
PRIME X399-A

IF YOU'RE GOING with the mighty powerhouse of Threadripper, you need a suitable motherboard. We admit, there's not a huge selection of X399 boards out there right now (seven in total), so pickings are slim, but that's not to say there's no choice to be had. In our opinion, Asus's Prime X399 is ideal. For this number of cores, unless you have very specific needs (overclocking, more PCIe SSDs, specific storage solutions, and so on), there's very little to justify investing in a pricier motherboard.

Asus's Prime X399 was the board we chose for our recent workstation rendering machine, because of these very reasons. We wanted to keep an eye on the price, yet still have access to a fantastically smooth BIOS for additional tweaking, overclocking, and more if we needed it. Throw in the gorgeously understated color scheme and design of the board, plus cooling and storage support, and it's an all-around no-brainer.

That said, one of the biggest reasons we chose this board is due to market share. Why? Simply put, Asus has loads of money and resources to invest in BIOS development, pushing the boundaries of memory support in the process—and good memory support is still key to unlocking the real potential of AMD's potent processor. Stability is also an important factor, and you can max both of those factors out using this powerful motherboard. Throw in the strong feature set and raw power on offer, and this is an easy recommendation to make.

CPU COOLERS

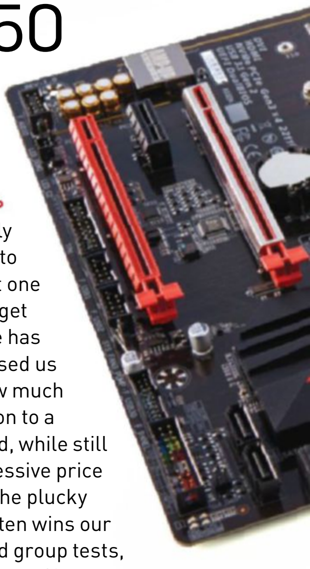
NZXT Kraken X62

$160 **www.nzxt.com**

IF CASH is tight, there's nothing wrong with using the cooler that comes with your CPU (as long as it's the retail version—OEMs don't have coolers). However, if you want to overclock, or keep temperatures down so your machine runs more quietly, water cooling gets the nod from us. Obviously, piecing together your own loop is the pro choice here, although for an easier life, an all-in-one cooler has a lot going for it. We've seen quite a few of these recently as new manufacturers enter the market, but the likes of the Corsair H110 ($124) and NZXT Kraken X62 ($160) still stand out as the ones to buy.

Gigabyte AB350 Gaming 3

$110 **www.gigabyte.com**



NOW WE TURN to our budget-specced motherboard of choice: the Gigabyte AB350 Gaming 3. Ryzen is an absolutely revolutionary product, chipset and all. Just how far it's shifted the processor industry is something we may never know for sure, but the fact that you can now invest in a quad-core i5 equivalent for less than $130 certainly makes it a force to be reckoned with.

Couple Ryzen with Gigabyte's fantastically well-designed AB350 Gaming 3, and you're quickly on your way to speccing out one hell of a budget rig. Gigabyte has long impressed us with just how much it can cram on to a motherboard, while still hitting aggressive price points, and the plucky underdog often wins our motherboard group tests, purely because of its crazy design ethos.

There's a whole heap of motherboards available for

RAM

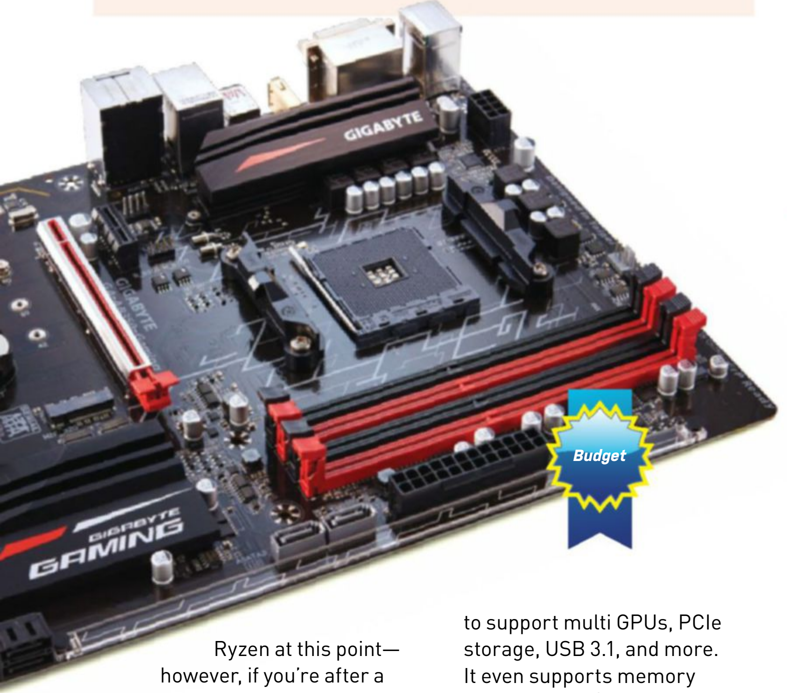
Corsair 32GB Dominator Platinum 2,400MHz

$330 www.corsair.com

IT ISN'T A great time to upgrade memory right now. Not because there's no benefit in giving your OS and apps more room, but because pricing is currently horrible. Memory pricing has almost doubled in the last 12 months, so while we'd love to recommend that everyone aims for at least 16GB in their systems, it's a tough call to make when even a budget kit will set you back nearly $150.

Aim for 8GB as an absolute minimum for most normal use, although 32GB is nice for serious work. If you've got room to double up on what you've already got, do so, because hopefully pricing will calm down by the time you upgrade again. When it comes to what to buy, aim for capacity first and frequency after. Low latency kits are the way to go if you can afford them, although given the current inflated pricing, being picky will cost you. As an example, you can pick up DDR4 kits rated at up to 4,600MT/s (PC4 36800 with 19-23-23-43 timings), although you will pay a lot for the privilege ($430-plus for 16GB).

It's worth noting that Ryzen benefits from faster memory, because its infinity fabric operates at the speed of the memory, but be mindful of compatibility—check your mobo's supported memory list for capacity and speed first.



Ryzen at this point—however, if you're after a no-fuss, plug-and-play build, the AB350 is where it's at. This board isn't for tweakers—you won't be able to overclock on it—but it does provide you with everything you'll need to support multi GPUs, PCIe storage, USB 3.1, and more. It even supports memory up to 3,200MT/s as well, meaning you can net yourself a 10–15 percent increase in performance in some cases, just by turning on the AMD memory profiles.

Asus RoG Maximus X Hero

$280 www.asus.com

WE HAVEN'T HAD chance to play with a lot of Z370 motherboards yet (we have some seriously juicy ones coming up next issue), because as this issue goes to press, Coffee Lake will have only just dropped. That said, it's hard to argue with the Asus ROG Maximus Hero's heritage. We've been using this lineup of motherboards in our test benches since Devil's Canyon and Z97.

The Asus ROG Maximus X Hero is a fantastic update to the series, featuring an integrated rear I/O cover, oodles of USB ports, BIOS reset switches, Ethernet ports, integrated Wi-Fi, dependable audio, a ton of onboard storage support, M.2 heatsinks, and more. One of the things we've already touched upon with our love for Asus is just how easy it is to use the UEFI BIOS. It may be difficult to quantifiably review a BIOS, because those familiar with one manufacturer's BIOS will almost always know how best to take advantage of that compared to another, and it's often personal preference that dictates the issue; however, the placement of menus, along with the options and items you can tweak in Asus's BIOS make it one of the more intuitive and easy-to-use that we've seen in the last few years.

This board is a touch on the pricey side, but if you're looking to shell out on a high-end Coffee Lake processor, it's well worth the investment.

SOLID-STATE DRIVES

Samsung 960 Pro

$295–$1,265 www.samsung.com

NO-BRAINER TIME: If you want the fastest storage around, you'll want an SSD. Not just any SSD either—you'll want a PCIe M.2 drive that is capable of producing the kind of transfer rates that make grown system admins weep. And at the top of that pile of drives at the moment is Samsung, with its 960 Pro range of M.2 drives, where you'll see sustained transfer reads and writes of 3,400MB/s and 2,100MB/s respectively. The random 4K performance is no slouch either, hitting 57MB/s and 194MB/s when throwing around smaller files.

You'll notice that we haven't specified a capacity with our recommendation, and that's because we suggest getting the biggest drive you can afford, without getting silly; $295 will net you a fairly sizeable 512GB model, which is more than enough for your OS and your main applications. Jumping up to a 1TB drive means you can hold a good chunk of your data on the drive as well, with the pricey 2TB model allowing for serious data usage.

HARD DRIVES

HGST HE10

$370 www.hgst.com

HOW MUCH storage do you really need? We're assuming you have some form of network attached storage, a good sized SSD, plenty of backup options, and a healthy chunk of online storage, like any good setup. So what's left? Some extra space is nice, sure, but unless you have specific requirements, a 1TB, 2TB, or 4TB hard drive is probably all you need, and will set you back $50–$180. You can now pick up hard drives up to 12TB, although they cost over $500. This 10TB model is a little more reasonable.

Samsung 960 Evo

$150-$465 www.samsung.com

SAMSUNG is the go-to company for high-end SSDs, but it's also our recommendation for the mid-range. The 960 Evo mixes a lot of the same magic as the 960 Pro, but at a lower price. The big difference is the type of NAND used: The 960 Pro uses MLC (Multi-Level Cell) flash, while the Evo uses TLC (Triple-Level Cell). They're both 3D NAND architectures, but the Pro manages to squeeze more into the same space, which is why it's available in larger capacities—512GB–2TB, while the Evo ships at 250GB–1TB.

Performance-wise, there is a difference between the Pro and Evo, but it isn't huge—sustained reads and writes of 3,200MB/s and 1,800MB/s aren't too far off the Pro. In fact, there are benchmarks that can see the Evo ahead of the Pro. It's worth noting that the 960 Pro does have a five-year warranty (or 800TB written), while the 960 Evo only has a three-year warranty (or 400TB written).

Crucial BX300 480GB

$145 www.crucial.com

ONCE YOU'VE used an M.2, you can't go back. To be fair, that's not strictly true, but it's a good sound bite, and there are some transfers where you can notice the difference. Not every system has access to M.2, though, and even those that do tend to be limited to one or maybe two slots. M.2 drives also demand a slight premium over 2.5-inch SSDs. That means there is still a market for the more traditional SSD, and such drives are still the go-to upgrade for anyone who is still running a spinning hard drive.

The Crucial BX300 is our new favorite budget SSD, packing half a terabyte for a wallet-friendly $145. As with any modern SSD, performance is decent enough, although you'll find that the straight throughput of any SSD that uses SATA is ultimately limited by the interface. You can check out the full review of this new drive on page 86.

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CASES

Phanteks Enthoo Evolv TG $180

www.phanteks.com

CASES ARE INEVITABLY a very personal thing for many people. After all, a big factor is aesthetics. Whether you care can dictate how much you're willing to spend. Looking for a super-slick, clean build? Then it's likely you're hunting for a svelte, aluminum, tempered glass solution. Couldn't give a damn? A square tin can sans window will do the job just fine.

That said, if you're building a premium system, you can't go wrong with a premium chassis. Ease of building, materials, paint finish, and internal cable routing options all contribute to a happier enthusiast.

For us, all this is epitomized by Phanteks—the Dutch company has a knack for making the premium affordable, and nowhere is this more apparent than the Phanteks Enthoo Elite TG. Featuring 4mm thick aluminum, tempered glass, and a sandblasted finish, combined with extensive cooling and storage support, it's definitely one of the best chassis out there for any custom system.

Fractal Design Meshify $90

www.fractal-design.com

ANOTHER ONE of our favorite case manufacturers is Fractal Design. Although typically catering more toward the no-fuss, silent, budget-oriented options with its Define series, Fractal provides a plethora of more exotic styled, cooling-heavy cases for those tempted into the heady realms of custom PC perfection, all without breaking the bank.

The Meshify is a perfect example: a small, stylish, mid-tower design, developed with maximum airflow in mind. The polygon-esque 3D diamond mesh front panel lends itself to up to 360mm radiators, and although liquid cooling isn't the best solution, it's perfect for AIOs and smaller form factor builds. Despite its low price, it supports up to three 2.5-inch SSDs on the rear of the motherboard tray, two 3.5-inch hard drives below the PSU cover, and a full-sized ATX PSU. Couple that with the inclusion of fan filters, solid cable management, and a smoked glass side panel, and you start to wonder where the corners were cut when designing this beauty. We'll let you know—if we find them.

DISPLAYS

Asus PA329Q $1,250

www.asus.com

RECOMMENDING a display is tricky because there are so many subjective variables. What may be perfect for one may not work for you. Gamers, for instance, want to prioritize the high refresh rates and low latency of a TN panel over IPS's color accuracy and viewing angles, while video editors may prefer the higher contrast ratios of VA panels.

Most of us want the best of all worlds—which tends to mean IPS panels, although newer tech is blurring these lines. Add in screen sizes, native resolutions, FreeSync/G-Sync, high dynamic ranges (HDR), and more, and it's clear that recommending a screen is difficult. We're still searching for the "perfect" panel at a price we're comfortable with—the Asus PA329Q is great, but at $1,250, it's not for everyone.

Corsair Carbide 270R $70

www.corsair.com

$70 IS A FAIR amount of cash when building a budget rig. We usually recommend you try to save as much money as you can on parts—apart from your PSU, CPU, GPU, and RAM. After all, you won't gain much from a case upgrade compared to those four components.

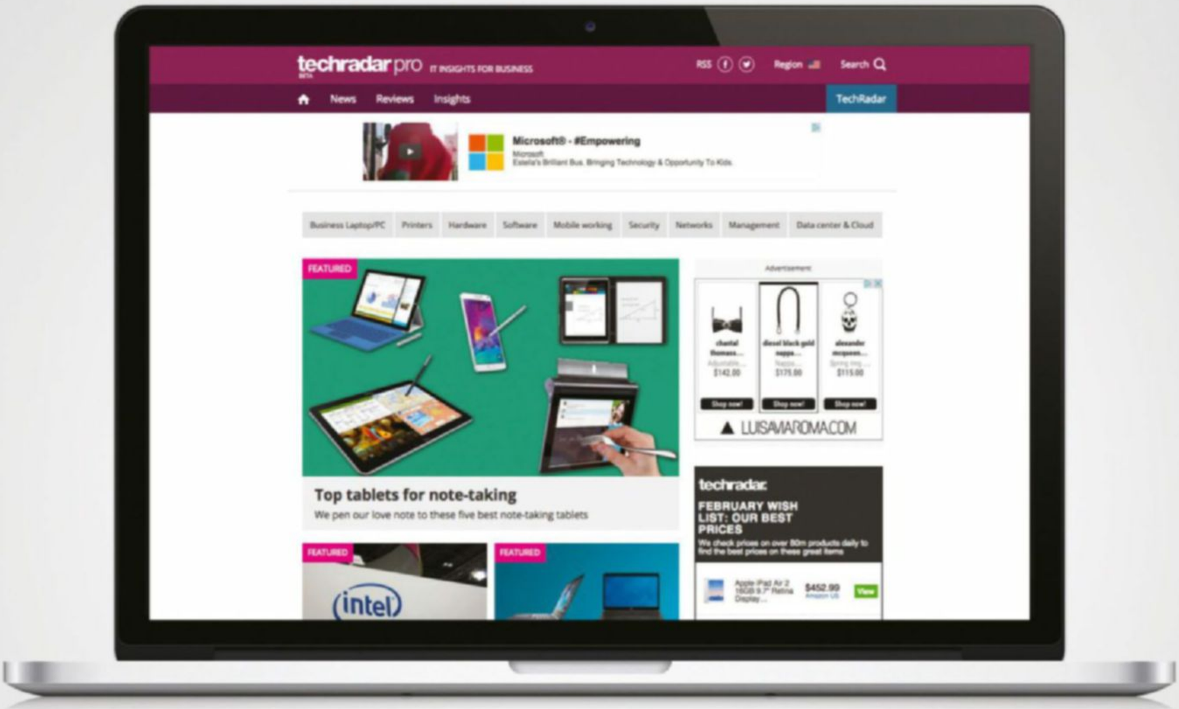
But if you're looking for a cheeky cheap upgrade, nothing's more satisfying than upgrading that old hunk of metal in which you house your precious hardware. Corsair's Carbide 270R hits that mark perfectly. With a simple, elegant design, the 270R would look as at home in a bedroom as in a game dev's studio. With support for up to three 120mm fans in the front, two 140mm ones in the roof, and four hard drives, it's not that different from the more expensive Fractal Design Meshify.

It's not perfect, but for the cash, you'd be hard pushed to find better than Corsair's aggressively priced, budget-busting box.

Future

techradar.pro

IT INSIGHTS FOR BUSINESS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PUT YOUR P

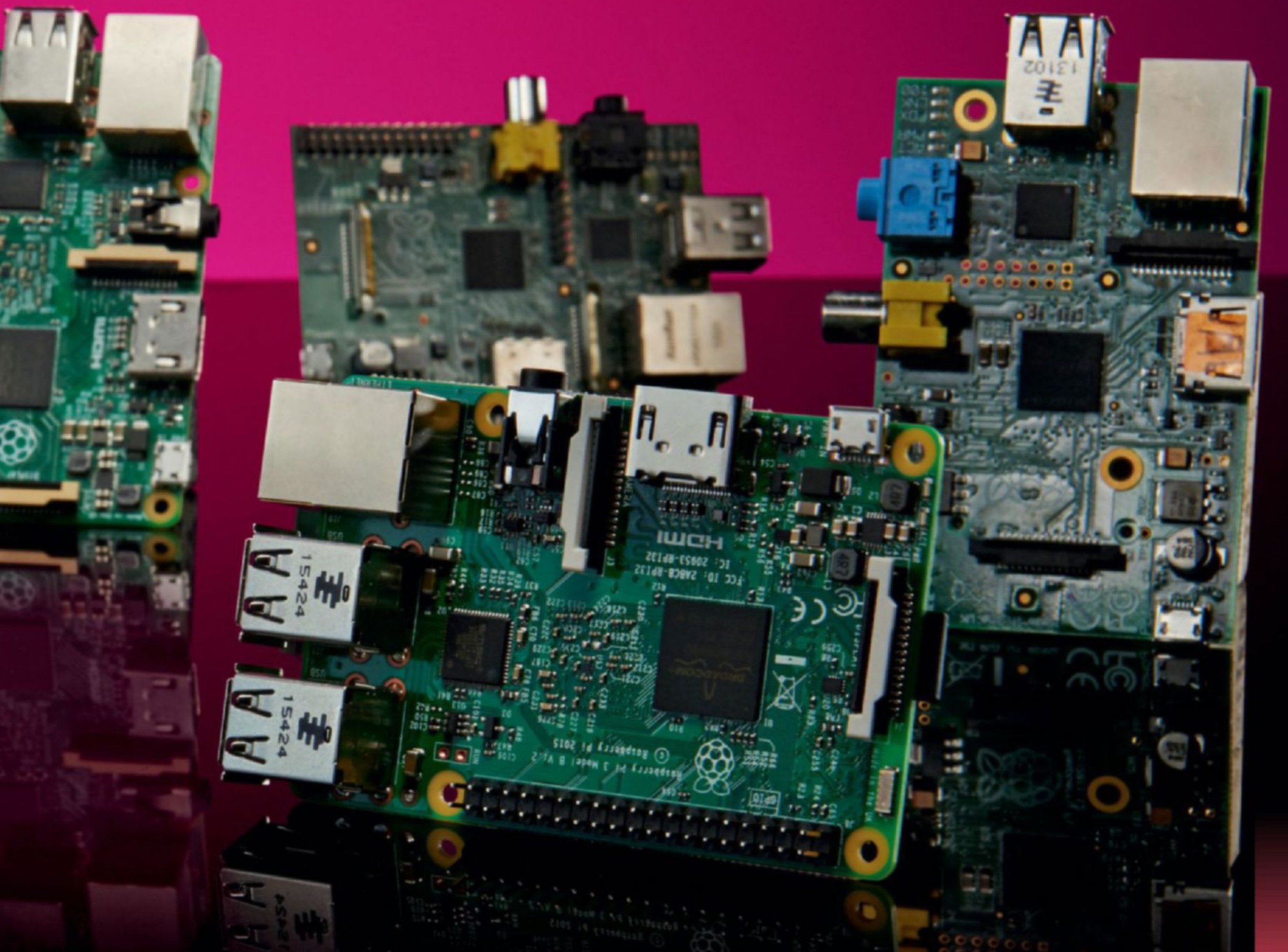
Alex Cox reveals diverse ways to give the single

There's a big problem with the Raspberry Pi, and that's the price. It's too cheap. $35 might make it accessible to the widest possible audience, but it also makes the Pi a perfect impulse buy—and don't even get us started on the gumstick-sized, Happy Meal-priced Raspberry Pi Zero. Low cost, tiny size, minimum appreciation—and that's a crime. There are thousands of perfectly capable Raspberry Pis in drawers and junk boxes across the world doing nothing but collecting dust, because their owners didn't have a plan. And it's time to change that.

So, dust off that unloved hardware, put visions of the slightly underwhelming Raspbian desktop experience behind you, and stop worrying about the dark depths of Linux. Achieving everything we're going to show you here is plausible for just about every user, command-line veteran or not, and every one of these potential projects will put your Pi to work around your home. Maybe it'll find its niche tucked away next to

i TO WORK

board computer a job and make it earn its keep



your router, silently earning its keep as part of your network lineup. Maybe you'll be able to make it part of your home entertainment setup, loudly working as a media streaming box. Perhaps you'll even add hardware to your Pi, taking advantage of its extendable architecture to turn it into something more. Every one of these ideas is the start of a new journey. Each aspect is yours to personalize, to improve, to expand on.

Whatever you decide to do with it, we do have a key recommendation: Ensure you're supplying power to your Raspberry Pi with an appropriate USB power supply. If you don't feed it the 2.5 amps it desires, you're likely to get severely degraded performance, but be careful to buy a quality PSU. We've seen (and bought, and safely disposed of) some horrific budget wall warts that look as adept at starting a house fire as they are at juicing a single-board computer. Many of these ideas will see your Pi powered up at all times, so something safe, efficient, and reliable is a must.

Networking

THE RASPBERRY PI is a great device to tuck away on a network. It's silent, it draws little power, and it can add the same functionality to your home setup as many rack-mounted appliances do to large businesses. Don't expect enormous throughput or the capability to handle massive amounts of traffic, but the Pi is the perfect companion for a home network.

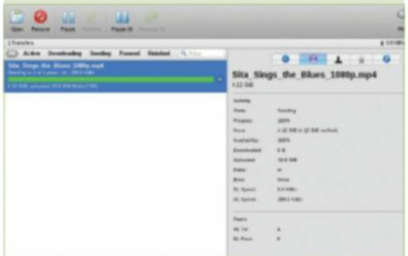
Develop New Embedded Systems

YOU'LL NEED TO GET a little hardcore for this one. Nard—Not Another Raspberry Distribution—is, as its name suggests, not actually a distro at all. It's a development kit for embedded systems. Install it on an SD card, and your Pi will boot the entire OS into RAM, leaving you free to remove the SD without damaging the system. You then get a truly headless box to work with as you wish, logging in through a web interface, adding packages via an SD card, or—if it's misbehaving—communicating through its USB null modem connection. You're then free to build whatever system you require from its wide selection of lightweight apps, or by making use of the Debian compatibility layer. **http://arbetsmyra.dyndns.org/nard/**

Build a BitTorrent Box

GRAB YOURSELF SOME storage—an external hard drive, large USB stick, or similar—and hook it up to your Pi, because it's time to fill it with Linux ISOs and historical artifacts from http://archive.org. Using a Pi as an always-available torrent client makes sense; the protocol is based on sharing and availability, but leaving your main PC ramping up your electricity bill isn't the right way to go about hosting that data. Run Raspbian, install torrent client Transmission with `sudo apt-get install transmission-daemon`, then immediately stop it with `sudo service transmission-daemon stop`, so that we can edit its configuration file. Run `sudo nano /etc/transmission-daemon/settings.json` to do so.

Find the line that says "rpc-whitelist," and add a comma after "127.0.0.1" followed by—if your network hands out IP addresses in this range—"192.168.1.*" and tweak that address range if required. Then head to "rpc-authentication-required," and change its value from "true" to "false." Exit Nano with Ctrl-X then Y, and run `sudo service transmission-daemon start` to set Transmission running again. You should now be able to log in to Transmission's web interface from any machine on your network, by pointing a browser at, for example, 192.168.1.2:9091, switching the IP address for that of your Pi.



ARMed with
by
Hypriot
The Docker Pirates

Run Pre-Packaged Applications

NARD A LITTLE TOO COMPLEX FOR YOU? How about trying out Docker, and using its containers to install full-featured web apps on your Pi with no configuration? You can't run too many concurrently on the Pi, because each individual container's VM snatches some of its limited system resources away, but something such as ResinOS (www.resinos.io) or HypriotOS is the perfect way to throw up a quick file server, database, or web stack as and when you need it. The fine folks at Hypriot have even built a number of useful, shaved-down, Pi-compatible containers for tons of tasks, which you can find at https://hub.docker.com/u/hypriot. **www.hypriot.com**

Set Up a PBX

A PBX—OR SWITCHBOARD—is a great thing to play with. While you can hook up a physical phone line to your Pi via hardware, it's more practical to route a SIP-linked number (from the likes of Skype) or a Google Voice account, which translates PSTN to VoIP for you. Asterisk, a seasoned PBX, can route calls through your home, deal with conference calls, and more—and the inclusion of the FreePBX web front end makes its dedicated distro more fathomable than setting it up from scratch. **http://raspberry-asterisk.org**

Host a Website

THERE'S A STANDARD stack of packages used to run a basic website: Linux, the Apache webserver, MySQL to handle the database side of things, and PHP to interact with that database. Setting up a LAMP stack isn't difficult—you can do it with `sudo apt-get install lamp-server` on Raspbian—but with one on your Pi, you can forego the cost of server hosting, and take full control over what you install and what you put online. Redirect web traffic to an open port on your home network with a service such as Dyndns.org, and you're set, though the Pi can only handle minimal traffic. **http://apache.org**

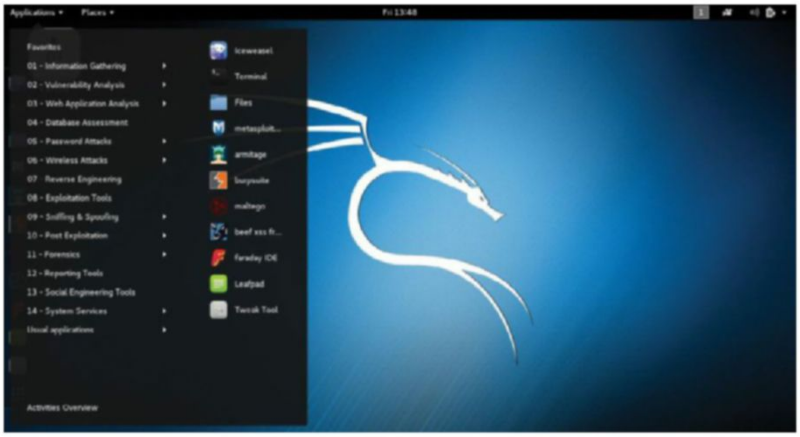
Build a File Server

IF YOU'RE LEAVING a Raspberry Pi running at all times, it might as well make itself useful. Setting up a Samba share means you (and other users of your network) can store files on it, and because Samba incurs little system overhead, it's realistic to install it on a machine that's otherwise dedicated to a different task. Open a terminal, and type `sudo apt-get install samba samba-common-bin` to install it.

Next, `sudo mkdir -m 1777 /share` creates a shared directory in the root of your SD card, gives everyone permission to read and write to it, and uses the sticky bit (the "1" in "1777") to stop it being deleted. Run `sudo nano /etc/samba/smb.conf` and add the following to the config file:

```
[share]
Comment = Shared folder
Path = /share
Browseable = yes
Writeable = Yes
only guest = no
create mask = 0777
directory mask = 0777
Public = yes
Guest ok = yes
```

Set up a password for your share with `sudo smbpasswd -a pi`, restart Samba with `sudo /etc/init.d/samba restart`, and you're all set to go. On a Windows machine, you should see a machine called "Raspberrypi" in the "Network" section of Explorer—open it, and you'll find your shared folder.


Applications ▾
Places ▾
Favorites
01 - Information Gathering
02 - Vulnerability Analysis
03 - Web Application Analysis
04 - Database Assessment
05 - Password Attacks
06 - Wireless Attacks
07 - Reverse Engineering
08 - Exploitation Tools
09 - Sniffing & Spoofing
10 - Post Exploitation
11 - Forensics
12 - Reporting Tools
13 - Social Engineering Tools
14 - System Services
Usual applications
Activities Overview
Iceweasel
Terminal
Files
metasploit...
armitage
burpsuite
maltego
beef xss fr...
faraday IDE
Leafpad
Tweak Tool

Pen-Test Your Devices

HOW VULNERABLE is your network and the machines on it? Penetration testing distros such as Kali Linux aim to give you all the tools you need to hammer your own hardware. And we do mean your hardware, because this entails turning your Pi into a toolkit that could cause chaos when plugged into any other network. Like taking a crowbar to a windshield, it's liable to land you in jail if that windshield doesn't belong to you. Kali is a mature pen-testing distro, with over 600 tools for everything from vulnerability exploration to wireless attacking and digital forensics. **www.kali.org**

Route Your Network Traffic

LET'S BE BLUNT: a Pi isn't the best choice of hardware for a router; its Ethernet port sits on its single USB 2.0 bus, bottlenecking its data allocation between all devices, so you're likely to top out at 50Mb/s throughput. That said, a lot of routers aren't the best choice for a router, as they're filled with dumb software that wouldn't know a packet from a hole in the ground. OpenWRT is replacement router firmware that gives you pinpoint control; if your hardware doesn't support it, switch into modem mode, and send traffic through OpenWRT running on a Pi. **www.openwrt.org**

Protect Your Network

THE WINDOWS FIREWALL is a formidable foe, but it's useless at protecting anything other than the machine it's on. So, your phone, tablet, and IoT fridge are all vulnerable. Unless you put something in the way, and don't mind sacrificing even more data than you would with OpenWRT. Using a USB Ethernet dongle, you'll be down to 25Mb/s per port. Forgive a little sluggishness, though, and a Raspbian-equipped Pi running Gufw is all you need to fend off an uncomfortable number of packet sniffers. Adding Pixelserv (http://proxytunnel.sourceforge.net/pixelserv.php) also blocks ads network-wide. **www.gufw.org**

OPENVPN
Your private path to access network resources and services securely
Cloud VPN
VPN Solution
VPN Service
Community
amazon web services
Downloads
Private Tunnel
iOS
FOR YOUR PC
FOR YOUR MAC
FOR YOUR ANDROID
FOR YOUR IPHONE/IPAD
Privacy Policy
Terms of Use
About
Jobs
News
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Partners/Clients
Support

Create a VPN Server

HOSTING YOUR OWN Virtual Private Network solves two key problems when you're away from the sanctuary of your home setup: It grants you access to your files and devices as though you were there, and it encrypts your traffic, obfuscating it from anyone who might be listening in on whatever seedy public Wi-Fi network you've managed to connect to. Leaving a home-based Pi running the OpenVPN server (you'll find it in your chosen distro's package manager) should do the trick, although RSA key configuration and the amount of IP table fiddling that's required mean this isn't the most trivial task. **http://openvpn.net**

Fun

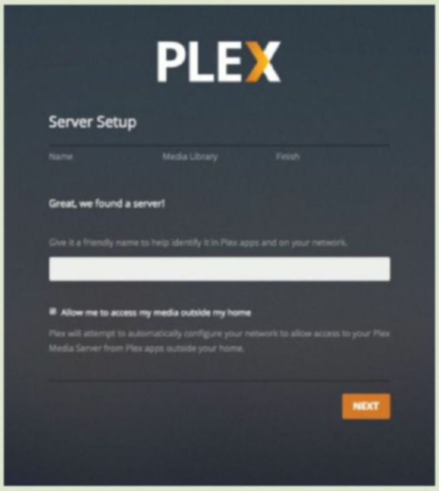
ALTHOUGH THE PI 3'S GPU runs at between 300 and 400MHz, it's remarkably powerful when you need it to be. A Pi attached to the back of a monitor discreetly transforms that screen into an all-in-one machine, and the range of single-serving entertainment applications the Pi can pull off is just remarkable. Grab an SD card, install, and enjoy yourself.

Network Audio Player

EASILY ENHANCED WITH AN ADD-ON DAC—the Allo Boss ($59) gives a massive sound and attaches to the Pi's GPIO pins—a Pi makes an ideal network audio player. There's a couple of ready-to-rock distros that aid in setting up support for the likes of Spotify, DNLA audio, web radio stations, and all the formats you could want. Our pick, Volumio, bills itself as "the open audiophile audio player," enabling you to fire off tunes using its comprehensive web interface on your phone or PC, and even offering its own hardware, including amps that do away with the need for anything beyond a pair of passive speakers. **https://volumio.org**

Plex Server

THE MORE WE cut the cord, the more we need other options for our TV viewing pleasure. If you've already amassed a large media library, Plex is a top choice: It's super-slick, fills up your library with cover images, theme songs, and episode information automatically, and requires very little in the way of technical knowledge to set up. It even streams online to your mobile devices. There's a catch, though: Running a Plex server on a Pi isn't really feasible if you want to enjoy your media in anything other than its stored resolution and format, because even the Raspberry Pi 3 doesn't have the required muscle for transcoding video. **http://plex.tv**



PLEX

Server Setup

Name — Media Library — Finish

Great, we found a server!

Give it a friendly name to help identify it in Plex apps and on your network.

☑ Allow me to access my media outside my home

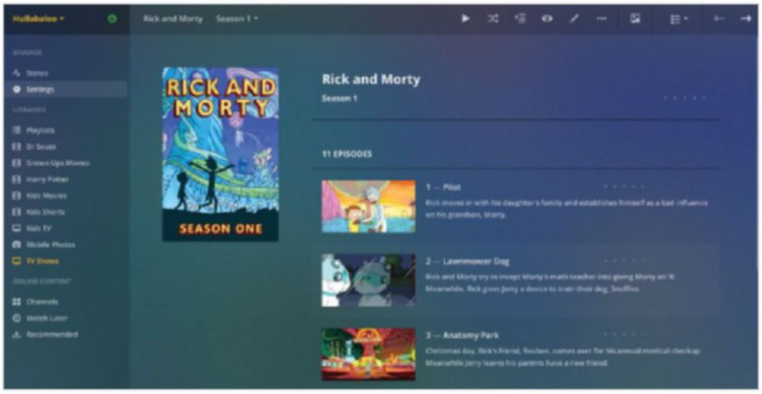
Plex will attempt to automatically configure your network to allow access to your Plex Media Server from Plex apps outside your home.

NEXT

Remote-Control the Raspberry Pi

IT'S FAIRLY EASY to attach wireless peripherals to the Raspberry Pi, and most should work without special drivers. Just plug in the USB portion and go, or use `sudo apt-get install bluetooth bluez blueman` to install Bluetooth management tools on the Raspbian GUI, then connect your devices from "Menu → Preferences → Bluetooth Manager." There's a command-line Bluetooth interface, which can be a bit more reliable, but it's tricky to get started with. If you're setting up your Pi to use as a living room media box, a combined mini keyboard and trackpad, such as the second-generation backlit Aerb (available for $17) is a great choice.

What if you want to get a bit more granular and old-school—not to mention technophobe-friendly—with your remote controlling? MSL Digital's RemotePi Board (http://msldigital.com) sits on top of a few of your Pi's GPIO pins, and is fully configurable to accept commands from whatever IR remote you point at it. MSL paints the RemotePi primarily as a power control board, fixing the key problem with the Pi's design, and letting you gracefully switch your media box on and off with a remote.

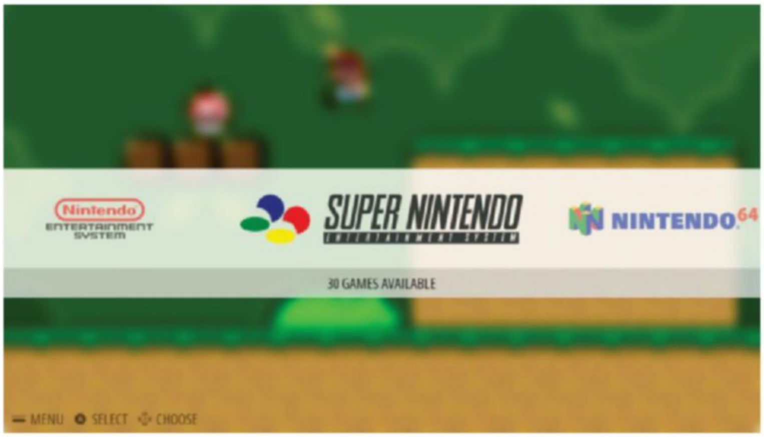


Plex Player

YES, WE LITERALLY just talked about Plex, but there's good reason to separate out the tasks of using your Pi as a server and as a player: It's far, far better at the latter. A Raspberry Pi 3 can easily handle 1080p video at 60fps, which is adequate for all but the most eagle-eyed 4K-fancying viewers. Install a distro such as RasPlex, and you'll be all but ready to go. Just connect to your TV, log in to your server, and you'll be playing back media in no time. All you need is a way to control it, and you'll find a few options above in the "Remote-Controlling the Raspberry Pi" box. **http://rasplex.com**

Emulate Classic Consoles

ANYONE WITH HALF AN EYE on the Raspberry Pi has probably heard of this one already, but we think it bears repeating: RetroPie is a simply incredible package of pre-configured, super-accurate console emulators, with a gorgeous front end supplied by EmulationStation. Most are built on top of the Libretro engine, which ties a number of different systems into a single package, meaning that you can make global changes to settings, which are automatically reflected across all platforms. Grab a USB adapter for your favorite set of console controllers—or just plug in a wired Xbox pad—and you'll be away. **http://retropie.org.uk**

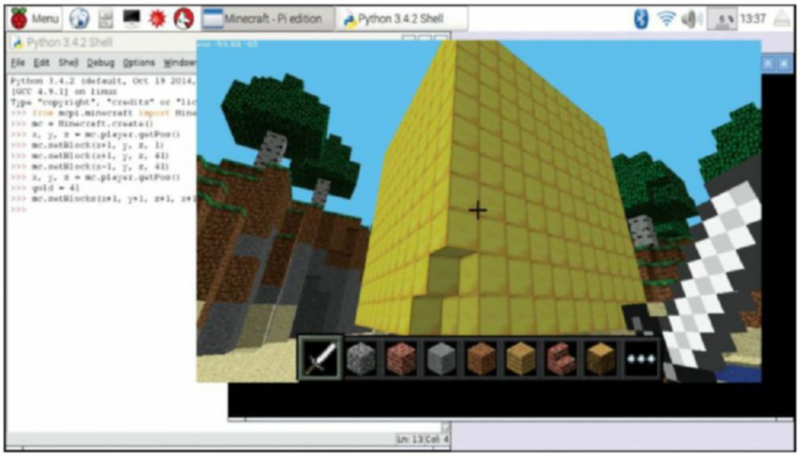


Keep Up with Kodi

KODI IS A BIG NAME in the streaming world, and not necessarily for the right reasons. Forget piracy, though: Kodi (once called XBMC, and spawned from a project that turned the original Xbox into a media center) really ought to be known for how easy it makes getting a media box up and running. It's supported by just about every Raspberry Pi distro. On Raspbian, you can install it using the following pair of commands in a terminal window:

```
sudo apt-get update
sudo apt-get install kodi
```

If that sounds too much like hard work, there is, like most of the projects we've talked about, a single-serving option to get a working Kodi installation running from scratch. In fact, there are several for you to choose from. OpenELEC (http://openelec.tv), the slightly more open source LibreELEC (http://libreelec.tv), OSMC (http://osmc.tv), and Xbian (http://xbian.org) all include Kodi pre-installed and configured, and are perfect if you're dedicating a Pi to the TV task; Kodi runs as both media server and player, so make sure you have some storage available for your content. You can also install Kodi to run through RetroPie, which is an immensely useful option.



```
Python 3.4.2 (default, Oct 19 2014,
[GCC 4.9.1] on linux
Type "copyright", "credits" or "lic
>>> from mcpi.minecraft import Mine
>>> mc = Minecraft.create()
>>> x, y, z = mc.player.getPos()
>>> mc.setBlock(x+1, y, z, 1)
>>> mc.setBlock(x+1, y, z, 41)
>>> mc.setBlock(x-1, y, z, 41)
>>> x, y, z = mc.player.getPos()
>>> gold = 41
>>> mc.setBlocks(x+1, y+1, z+1, x+1
>>>
```

Master Minecraft

THERE'S A VERSION OF MINECRAFT for the Pi (https://minecraft.net/en-us/edition/pi/), which is free, and a great way to get stuck into a bit of programing if you decide to wade into the code and hack it. You can also jam the full version of *Minecraft* on to a Pi 3 (www.raspberrypi.org/forums/viewtopic.php?t=186547), though it's a little experimental. Your Pi may be better put to use as a *Minecraft* server; there's enough power to host a few concurrent players of the full version, and while it's a little slow to generate new chunks, it's adequate. For better performance (with fewer features), try Cuberite, a multi-platform server designed to be lightweight. **http://cuberite.org**

Bring Back DOS

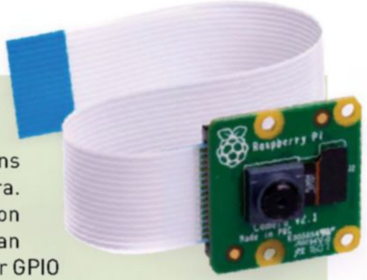
TRANSLATING X86 instructions to the RISC structure of an ARM chip takes a lot of processing power. It is possible to use virtual machine environment QEMU (http://qemu.org) to emulate a 486-class PC on a Pi, and you can even run a treacle-slow Win 98 install on top. But that's ridiculous. Instead, try the ARM port of DOSBox, so you can resurrect the classics without having to dredge up a machine that'll deafen you and double your electricity bill. Just run `sudo apt-get install dosbox` from the Raspbian package manager. To get really authentic, dig out that old box of floppies, and use a USB floppy drive to read them. **http://dosbox.com**

Play Arcade Games

THE RASPBERRY PI'S ARM architecture might not lend itself to some of the applications that x86 machines handle with aplomb, but it's absolutely perfect for emulation. So, let's take a trip through the old school by running classic arcade games on the miniature marvel. While it's not been updated for a while, we place PiPlay (formerly PiMame) at the top of the list for running the collection of legal MAME ROMs available from http://mamedev.org/roms, and only those ROMs. We couldn't possibly say how well it runs any other ROMs. **http://piplay.org**

Hardware

THE RASPBERRY PI was designed from the very beginning to give you control. Its bank of General Purpose Input/Output (or GPIO) pins are there so that you can read in signals from sensors, fire out signals to devices, and extend the Pi's capabilities with Hardware Attached on Top (HAT) boards. And so you should.



Security Made Easy

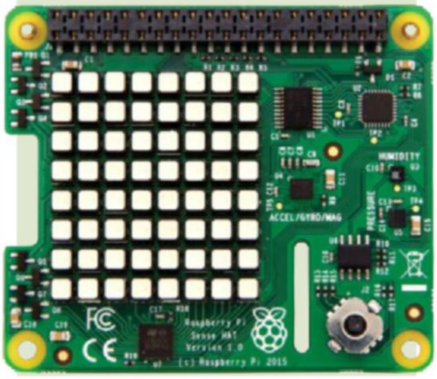
ONE OF THE FIRST HARDWARE add-ons for the Raspberry Pi was a camera. Indeed, there's even a special header on the board for such a device, so you can hook it up without blocking any of your GPIO pins. The second-generation sensor, available in both regular or infrared flavors for $25, can take 8MP snaps or stream 1080p video at 30fps, and is supported by plenty of software within the Raspbian ecosystem. Add in a bunch of IoT motion detectors and door switches, and you can (with a little effort) build your own home security system that you can monitor from your smartphone. The PrivateEyePi project has everything you need to get started. **http://projects.privateeyepi.com**

Your Own Project

THE PI IS DESIGNED as an educational, experimental board. You can use it to follow; there are plenty of projects where others have done the hard work for you. Or you could use it to lead; make something new. Turn that invention in your head into reality.

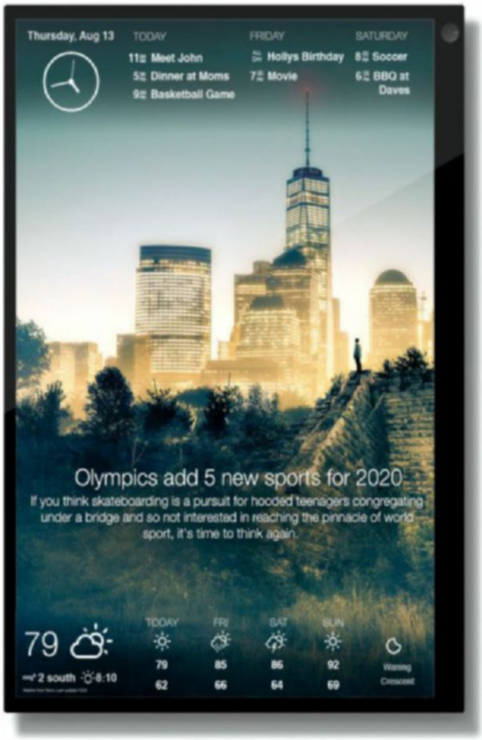
If this appeals, there's a pair of add-on boards that appeal to the tinkerer. The first is the Sense HAT ($40, www.adafruit.com), a combination of sensors (gyroscope, magnetometer, accelerometer, et al) along with a joystick, and an LED matrix display. This is the board that made it to the International Space Station as part of the Astro Pi project, and includes a Python library to allow you to access everything the board has to offer.

The other, which has been making waves more recently, is the MATRIX Creator ($100, http://creator.matrix.one). Designed to facilitate quick hardware prototyping, it includes libraries in multiple programing languages, an eight-point MEMS mic array, a programmable FPGA, a bunch of 3D sensors, and a waterfall of connectivity options to interface it with whatever hardware you like.



Wall-Mount Your Pi

TAKE AN OLD MONITOR, a VESA mount, and a Raspberry Pi. Screw the lot to your drywall, and you've got something special: a screen that can cycle through your photos, give you at-a-glance news information, remind you of calendar appointments, and much more. Registering a free account with DAKboard and setting your Pi to run Chromium in kiosk mode is basically all you need to do. You can customize the display through DAKboard's web interface, and grab additional features such as calendar customization and weather data with a small monthly subscription. **http://dakboard.com**



Olympics add 5 new sports for 2020

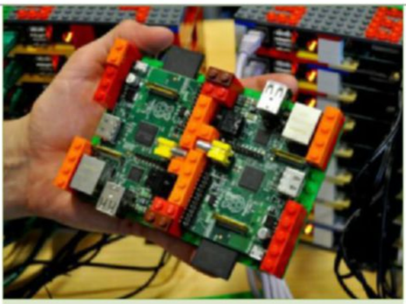
If you think skateboarding is a pursuit for hooded teenagers congregating under a bridge and so not interested in reaching the pinnacle of world sport, it's time to think again.

Make a Magic Mirror

YOU KNOW HOW good-looking you are. And your mirror knows, too. But what if it knew more, and could tell you information about the day to come while you gaze at yourself? Combine half-silvered glass with a Pi-equipped monitor, and this can be yours. Dutch hacker Michael Teeuw developed the magic mirror in 2014, and it's been replicated by hundreds of enthusiasts since, and has spawned modules, tweaks, and ideas that can help you develop a custom mirror of your own. **http://magicmirror.builders**

Monitor the Weather

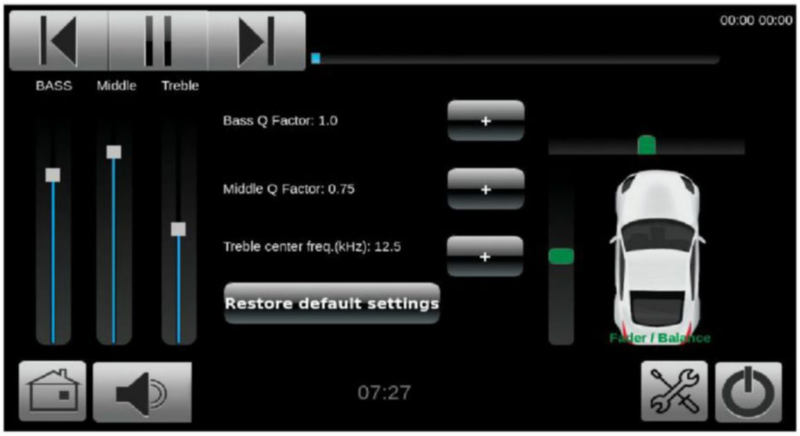
WITH ONLY $88-worth of parts—including the Pi at its heart—you can construct a weather station that monitors humidity and temperature, then logs it to a web interface. It's a great way to learn a bit of Python, pick up the basics of interacting with sensors, and create a project that you could extend later on. It's not as full-featured as the weather station the Raspberry Pi team gave out to schools (http://raspberrypi.org/education/weather-station), however Raspberry Weather's tutorial is a valuable resource that'll get you going fast. **http://raspberryweather.com**



Build a Cluster

EARLIER, WE MENTIONED the possibility of installing Docker containers on the Raspberry Pi. While they're excellent at getting preconfigured applications running, there's another aspect of Docker that suits the Pi's low cost and low energy footprint very well: Swarm mode. In essence, it's a simple way of setting up cluster computing, which combines multiple physical machines with networking to create a single logical machine. Hook up two Raspberry Pi 3 units as processing nodes, for example, and you'll have eight ARM cores and 2GB RAM at your disposal. Scale it up, and you'll outpace the processing power of the original Cray supercomputers with only a small investment.

Normally, this isn't at all easy, as anyone whose high school computer lab had them set up a Beowulf cluster of tired Pentium 2 machines will attest. Thankfully, the software wizards at Hypriot have developed the Cluster Lab, a super-simple way to set up a Docker Swarm with several Raspberry Pi units. Check out the instructions at http://github.com/hypriot/cluster-lab. In essence, you simply need to flash a specific OS image to each node, tell them they're part of a swarm, and they'll find each other, and work together automatically. Now it's just a question of what to do with your cluster...



Bass Q Factor: 1.0
Middle Q Factor: 0.75
Treble center freq.(kHz): 12.5

Upgrade Your Car

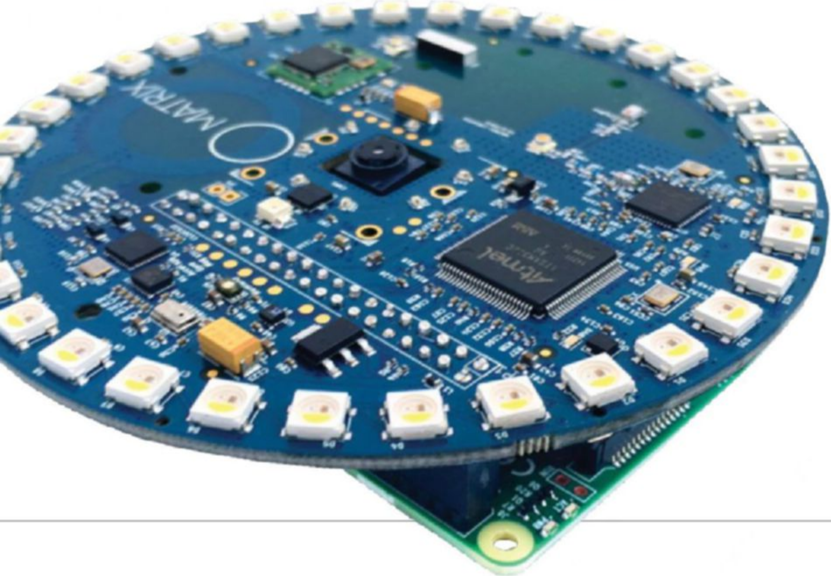
WITH A DOUBLE DIN-SIZED TOUCHSCREEN, a Pi, and possibly some in-car Wi-fi, you have all you need for an in-car upgrade. Will you use Navit (www.navit-project.org) to add a module, and set up your own GPS? Will you entertain passengers with an in-car media center? Perhaps you want to use your Pi to monitor your engine via your car's OBD-II port using a $20 Bluetooth module? The possibilities are myriad. The guys at iCarus can furnish you with everything from the software (which runs on Raspbian), to individual components, to entire pre-assembled units. **www.i-carus.com**

Build a Robot

SCRATCH IS THE PI'S key learner language. You can build complex programs by dragging and dropping elements of code, and filling in the odd variable here and there. But don't take that to mean it's simplistic. You can also use Scratch (or Python, or C) with a hardware control board, such as the Laika Explorer ($47), to interface with motors, servos, and sensors, turning your Pi into a full-featured robot. Laika's programing library is packed with all the functions you need to prototype a 'bot, so all you need to worry about is supplying the power. If you plan to give your creation wheels, we recommend an external battery pack. **http://project-laika.com**

Build an Arcade Machine

IF YOUR EMULATION interests have been piqued by PiPlay or RetroPie, Pimoroni's Picade HAT may be for you. Jam it on top of your Pi's GPIO pins, and you gain a 3W DAC for audio, power routing through its USB port, and screw terminals, enabling you to attach real arcade controls. It comes on its own ($15.75), with buttons and a joystick ($120), or as a mini cabinet with monitor ($240). Try spending a little more and securing authentic Sanwa or Seimitsu parts from www.focusattack.com to build your own. **www.adafruit.com**



Create a Voice Assistant

WHO NEEDS THE AMAZON ECHO? People who can't do things for themselves. With a Raspberry Pi, a suitable microphone, an external speaker, and a certain level of patience, you can create your very own voice assistant that uses precisely the same voice service that Amazon uses on the Echo, meaning you have access to all the skills and enhancements that go along with it, and it starts automatically when you power up your Pi. You need to register a free Amazon developer account in order to gain access to the API—and, if we're honest, the combined cost of hardware is greater than the price of an Echo Dot, but don't let a silly thing like that put you off. **http://github.com/alexa-pi**

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TECH PORN

Synology DiskStation DS418j

THE ONCE-HUMBLE network attached storage (NAS) device is enjoying something of a revolution at the moment. Once the sole preserve of clued-up IT professionals, these days you'll find these smart collections of hard drives in more and more homes. A lot of NAS manufacturers often try to bridge the gap between the needs of home and business with their latest models, but with the DiskStation DS418j, Synology is laser-focused on home users. This is a machine that is designed to stream your media to your TV just as much as it's geared toward housing backups of all the machines on your network.

Just because it's aimed at the home user, don't think for a second that it's lacking when it comes to specifications: The very fact it supports hardware encryption should be a good enough sign that this is a serious piece of gear. It's as easy to set up as you want, too, with support for the automated Synology Hybrid RAID taking the hard work out of creating a RAID, although it supports all the standard arrays as well, including RAID 0, 1, 5, 6, and 10, plus JBOD. At $299 for the diskless unit, it's not too costly, either. **–ALAN DEXTER**

1 DRIVE BAYS

Release the four thumbscrews on the back of the unit, flip the door down, and you have access to the four 3.5/2.5-inch drive bays. The DS418j supports up to 40TB of raw capacity, and you can set all of that up as a single volume, should you wish.

2 SOFTWARE

Synology's DiskStation Manager software is well respected for its versatility and stability, and it's reason enough to want to grab this unit, whether you're looking for centralized backup, media streaming, or a straight file server.

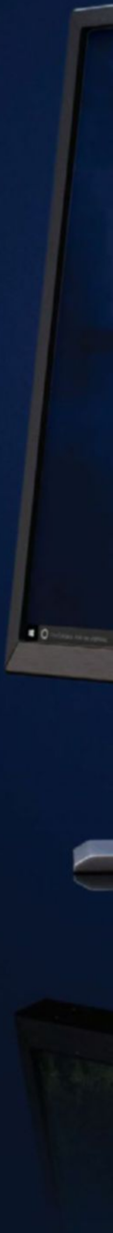
DS418j
LAN
HDD1
HDD2
HDD3
HDD4
Synology
Synology

3 HARDWARE

The DS418j uses a 64-bit, dual-core CPU from Realtek, running at 1.4GHz. It includes a hardware encryption engine, offering 112MB/s encrypted read and 87MB/s encrypted write performance. You also get 1GB of DDR4 to keep things running smoothly.

SPEED UP YOUR PC

Discover the tips and techniques you need to boost your PC's performance and lengthen its life. *By Nick Peers*



Does your PC struggle to keep up with the demands you place upon it? Do you think that it might be time to bite the bullet and buy a new one? If your PC is under five years old, there's a good chance you can extend its life without having to incur the cost of a total replacement. In this guide, we'll show you all the tips and tricks you need to speed up your PC—and many of the techniques we reveal won't cost you a dime.

There's the inevitable clean-up of course—most speed problems can be traced to the increasing load on your computer over time, so we'll start things off by stripping things back there. This is often compounded by the fact that Windows Updates can be less than optimal at cleaning up after themselves, so tossing out the junk, and getting rid of things you don't need can often have a significant effect on the overall speed of your machine. After that, we'll help you examine the time it takes your system to start up—not only will our tips and tricks eliminate boot-time bottlenecks, but you'll also free up more system resources, and give your computer a new lease of life. Honestly, even if your machine feels fine to you right now, speeding up your Windows boot can have a serious effect on your perception of how responsive it is (or isn't).

We'll then look into some clever system tweaks that can free up your machine even further, helping to improve its responsiveness and performance when heavier demands are placed upon it. And if there's a particular job you need to perform at the fastest possible performance, we'll show you how to strip everything else back.

Follow our guide to its end, and you'll wonder why you ever thought about replacing your PC, as it frees itself from its shackles, and really starts to fly.

BootRacer will measure your Windows boot time on the next reboot.

Would you like to restart your computer now?

BootRacer
Boot Time Test
Advanced...
Start
BootRacer
Yes
No
AGON

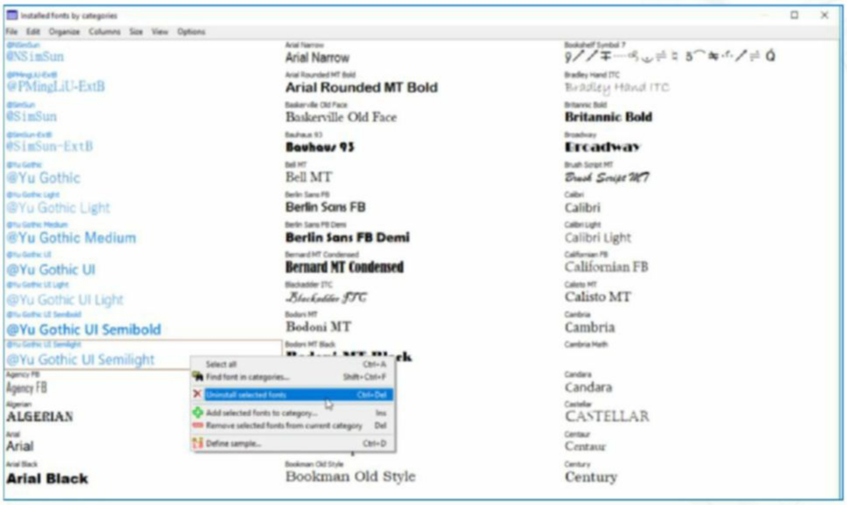
PERFORM A QUICK CLEAN-UP

Before you start targeting specific areas of your computer, begin with a much-needed clear-out of key areas of your system. Here's how...

Step one to speeding up your PC is giving it a clear-out. If your last spring clean wasn't long ago, you might be tempted to skip this, but you'll be surprised by how quickly detritus can accumulate, so these tips are still worth following.

First, we need to ensure there's sufficient free space on your system drive—aim to leave at least 5GB (preferably much more) spare. Open File Explorer, right-click your drive, and choose "Properties." Click "Disk Clean-up," wait for the scan, then click "Clean up system files" to find more files to clear out. You may need to scroll through and check further items to clean up; select each one to read more about it, as some—such as ESD files—are best left in place.

If you want to push things further—or you're still lacking free space—follow the "Clear Out Using CCleaner" boxout opposite. You can download and install CCleaner from www.piriform.com.


Installed fonts by categories
File Edit Organize Columns Size View Options
@NSimSun
@PMingLiU-ExtB
@SimSun
@SimSun-ExtB
@Yu Gothic
@Yu Gothic Light
@Yu Gothic Medium
@Yu Gothic UI
@Yu Gothic UI Light
@Yu Gothic UI Semibold
@Yu Gothic UI Semilight
Agency FB
ALGERIAN
Arial
Arial Black
Arial Narrow
Arial Rounded MT Bold
Baskerville Old Face
Bauhaus 93
Bell MT
Berlin Sans FB
Berlin Sans FB Demi
Bernard MT Condensed
Blackadder ITC
Bodoni MT
Bodoni MT Black
Bookman Old Style
Bookshelf Symbol 7
Bradley Hand ITC
Britannic Bold
Broadway
Brush Script MT
Calibri
Calibri Light
Californian FB
Calisto MT
Cambria
Cambria Math
Candara
CASTELLAR
Centaur
Century
Select all Ctrl+A
Find font in categories... Shift+Ctrl+F
Uninstall selected fonts Ctrl+Del
Add selected fonts to category... Ins
Remove selected fonts from current category Del
Define sample... Ctrl+D

Streamline your fonts and you might reclaim valuable resources on low-end systems.

Clear Out Unused Apps

It doesn't matter how diligent you are, at some point you'll start to accumulate redundant programs on your PC, each one demanding its share of space and system resources. You can manage these from the Programs and Features Control Panel (Windows 7 or 8.1), "Settings → Search and apps → App sizes" (Windows 8.1—Store apps only), and "Settings → Apps" (Windows 10—desktop and Store apps).

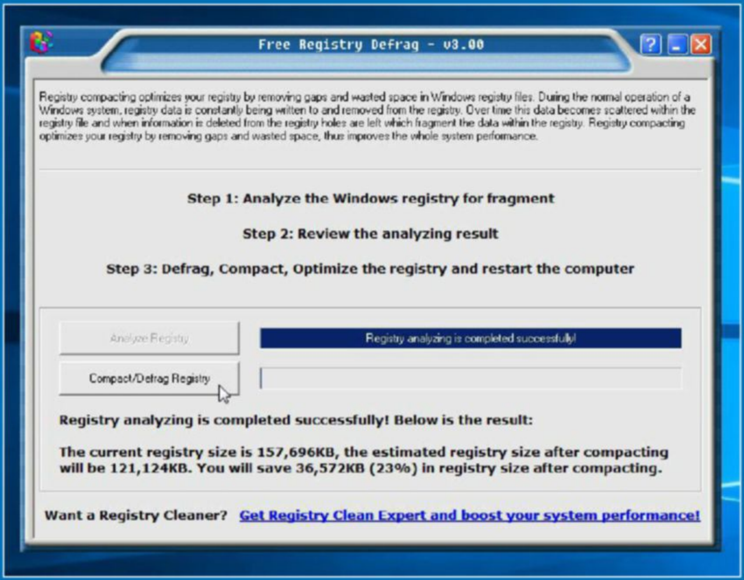
That's all well and good, but programs leave bits of themselves behind—leftover

REGISTRY CLEANING

Third-party clean-up tools—such as CCleaner—include Registry cleaning tools, with the promise of streamlining and speeding up Windows. These tools scan areas of the Registry for supposedly redundant entries, offering to delete them. Hundreds or even thousands of entries get removed at a time, but even if your tool doesn't accidentally delete an important Registry entry (and it will, sooner or later), Registry cleaning offers no benefit to performance whatsoever.

You can potentially improve performance—but not by much—by defragging the Registry files (known as "hives") using a dedicated tool, such as Registry Defrag Free (www.registry-clean.net/free-registry-defrag.htm). It analyzes the Registry and tells you whether significant "bloating" has taken place; if it has (over 10 percent), you can take a Restore Point, then let the program compress and defrag the files.

If you're running Windows on an SSD, however, there's little benefit in defragging the files. In most cases, you'll also find that Windows has done a reasonable job of keeping the hives in good order, making the process redundant.


Free Registry Defrag - v3.00
Analyze Registry
Compact/Defrag Registry

Registry compacting optimizes your registry by removing gaps and wasted space in Windows registry files. During the normal operation of a Windows system, registry data is constantly being written to and removed from the registry. Over time this data becomes scattered within the registry file and when information is deleted from the registry holes are left which fragment the data within the registry. Registry compacting optimizes your registry by removing gaps and wasted space, thus improves the whole system performance.

Step 1: Analyze the Windows registry for fragment

Step 2: Review the analyzing result

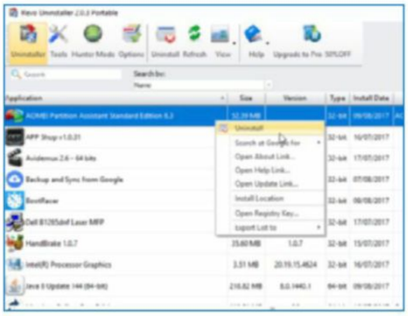
Step 3: Defrag, Compact, Optimize the registry and restart the computer

Registry analyzing is completed successfully!

Registry analyzing is completed successfully! Below is the result:

The current registry size is 157,696KB, the estimated registry size after compacting will be 121,124KB. You will save 36,572KB (23%) in registry size after compacting.

Want a Registry Cleaner? Get Registry Clean Expert and boost your system performance!



Revo Uninstaller is fast and unobstrusive, although it can feel a little basic.

files and Registry entries. If you don't plan to reinstall the app again, these can be safely deleted with the help of a third-party program, such as Revo Uninstaller Portable (www.revouninstaller.com—click "Downloads," followed by "Free Portable"). Note that Revo Uninstaller only works with desktop programs. You can clear out both desktop programs and Windows Store apps (including those pre-installed with Windows) using IObit Uninstaller 6 Free (www.iobit.com/en/advanceduninstaller.php) instead. Make sure that you skip the pop-up offer when you come to download it, and we also recommend installing Unchecky (www.unchecky.com) first—this will ensure that you don't inadvertently agree to installing the complete IObit Advanced SystemCare suite, as well as helping to keep other unwanted software off your system.

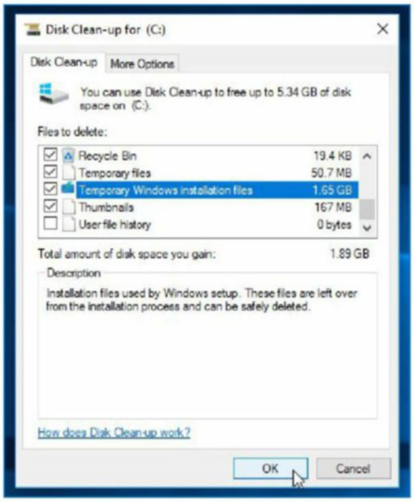
Both CCleaner and IOBit Uninstaller 6 Free work in the same way: Take a System Restore point if offered, then let the program's own uninstaller get on and do its job. Don't reboot if prompted; instead, run the scan to view and delete both leftover files and Registry entries. For more details, see the "Registry Cleaning" boxout on the opposite page.

While you're going through your installed apps—particularly if you're running a low-powered machine—consider ditching any resource-hungry programs for their lightweight equivalents. Microsoft Office, for instance, too much for your tablet or low-end laptop? Remove it and then install WPS Office 2016 (www.kingsoftstore.com) or LibreOffice (www.libreoffice.org) instead. Also, try switching to portable apps, where possible, to prevent clutter from accumulating on your PC's main storage drive—save these to a separate partition or drive instead, and they'll also survive Windows reinstallation, with all your settings intact, too.

Finish Your Clean-Up

Most of our lives are spent on the Internet, so if your web browser is starting to creak at the seams, consider taking steps to give it a clean-up and refresh. First, perform an audit of all the browser add-ons you've installed—the procedure for reviewing what's installed varies from browser to browser: Chrome users should type "chrome://extensions/" into the Address Bar, for example, while Firefox users can use "about:addons."

Disable or remove any add-ons or extensions that you no longer need—if you have a lot of items and multiple browsers to process, you'll find that both CCleaner ("Tools → Browser Plugins") and IObit Uninstaller ("Toolbars & Plugins") make it easy to manage everything from one convenient spot.



Disk Clean-up for (C:)

Disk Clean-up | More Options

You can use Disk Clean-up to free up to 5.34 GB of disk space on (C:).

Files to delete:

☑	Recycle Bin	19.4 KB
☑	Temporary files	50.7 MB
☑	Temporary Windows installation files	1.65 GB
☑	Thumbnails	167 MB
☐	User file history	0 bytes

Total amount of disk space you gain: 1.89 GB

Description

Installation files used by Windows setup. These files are left over from the installation process and can be safely deleted.

How does Disk Clean-up work?

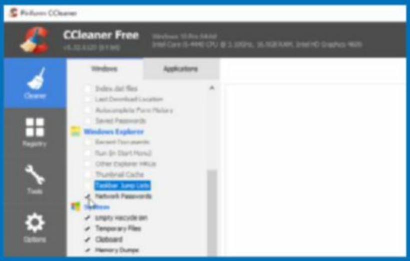
OK | Cancel

Start your clear-out with Windows' own Disk Clean-up tool.

Another area to focus on is fonts. If you have a lot of fonts installed on a low-memory PC, they affect performance. Manage them using AMP Font Viewer (www.ampsoft.net/utilities/FontViewer.php), which makes it possible to uninstall those you don't use regularly, loading individual or groups of fonts back into memory for temporary use when the need arises.

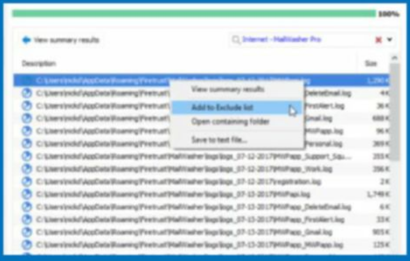
There's one major area we've yet to look at, and that's the start-up process. Turn the page for a complete guide to both monitoring the boot process and optimizing it to speed up how quickly your PC starts up. We'll also explain how to optimize system resources further.

Clear Out with CCleaner



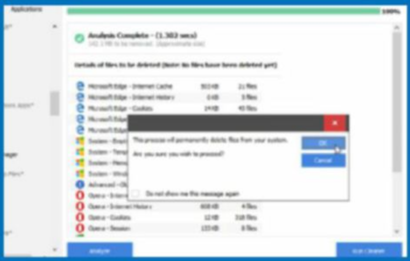
1. START CLEANING

Launch CCleaner. Go through the "Windows" and "Applications" tabs in the "Cleaner" section, reviewing each item, unchecking those you wish to keep. Pay particular attention to the "Windows Explorer" section. Once satisfied with what you've selected, click the "Analyze" button, and wait for the scan.



2. REVIEW CAREFULLY

When complete, a summarized list is displayed. Be sure to right-click any questionable items and choose "View detailed results." You can protect individual files from being deleted by right-clicking them and choosing "Add to Exclude list," or uncheck the list and click "Analyze" to perform a fresh scan.



3. RINSE, THEN REPEAT

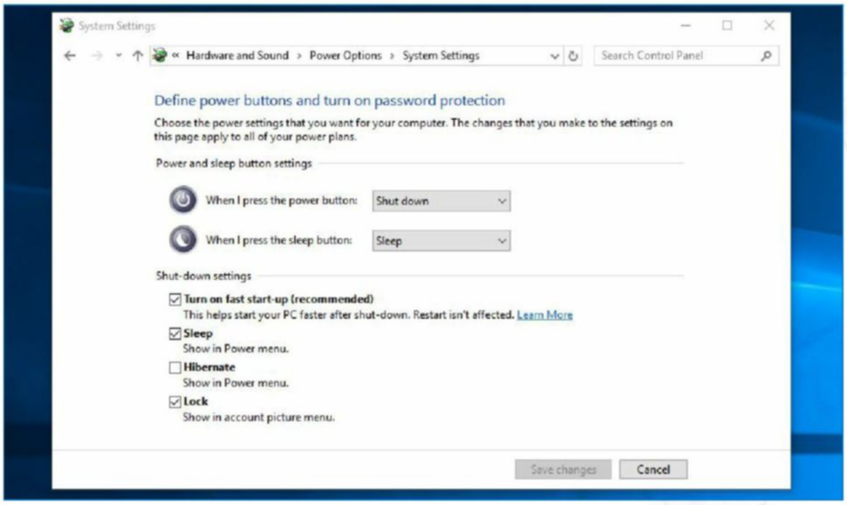
When you've finished reviewing everything, click "Run Cleaner." Read the warning—this is your last chance to turn back—and click "Yes" to delete the files. Going forward, you can run further scans, or quickly right-click individual categories in the list, and choose "Analyze" or "Run Cleaner" for a targeted clean-up.

SPEED UP STARTUP

Slash your boot times and free up vital system resources at the same time to give your PC a major speed fillip—this section shows you how

Over time, you'll notice how much longer it takes Windows to start up. Optimizing your startup times isn't simply about getting your PC to boot faster, though—it also has a beneficial effect on your machine's general performance. That's because, as you install programs on your computer, some of them configure themselves to load at startup. The process of loading these startup apps naturally lengthens boot times, but the apps also consume additional resources, producing a drag on your computer's overall performance, too.

Some startup processes—your security software for one—are essential, and shouldn't be touched. Others, such as your cloud sync app, are best left running, too, but you'll find many apps and programs aren't used often enough to justify allowing them to gobble up resources in the way that they do. The trick is identifying and disabling them.



System Settings

Hardware and Sound › Power Options › System Settings

Define power buttons and turn on password protection

Choose the power settings that you want for your computer. The changes that you make to the settings on this page apply to all of your power plans.

Power and sleep button settings

When I press the power button: Shut down

When I press the sleep button: Sleep

Shut-down settings

☑ **Turn on fast start-up (recommended)**
This helps start your PC faster after shut-down. Restart isn't affected. Learn More

☑ **Sleep**
Show in Power menu.

☐ **Hibernate**
Show in Power menu.

☑ **Lock**
Show in account picture menu.

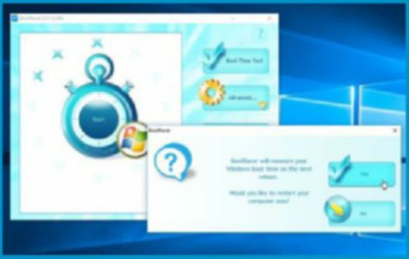
You can use a power plan to make your PC boot up faster.

Monitor Boot Times

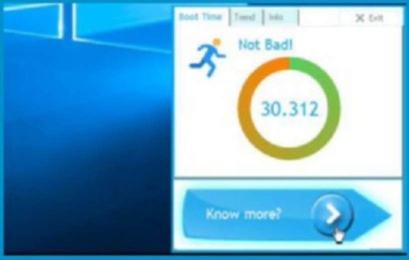
Startup programs aren't the only things that slow down Windows' boot time. The step-by-step guide below shows you how to monitor your boot time and manage startup programs using the free BootRacer app. You'll see that it divides the boot process into four stages. The first is pre-boot, and this covers the time it takes your computer to initialize its hardware and run various checks before handing over control to Windows. The figure should be three to five seconds on a PC with Fast Boot enabled—see the "Fast Boot" boxout above-right for more details.

If it doesn't appear to be enabled, type "power" into the Search box and click "Choose a power plan." Click "Choose what the power buttons do." If "Turn on fast startup (recommended)" isn't checked, click "Change settings that are currently

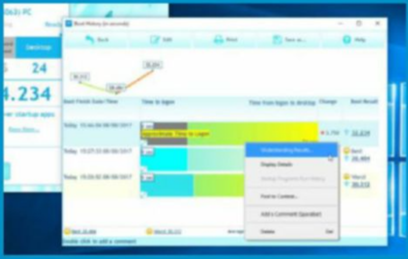
Measure and Improve Boot Times



1. FIRST STEPS
Download bootracer_freeb.zip from www.greatis.com/bootracer and extract the MSI file inside. Double-click this to install the program. Click "Finish" when complete. The main window opens automatically—click "Boot Time Test," then "Yes" to restart your PC and perform the first boot test.



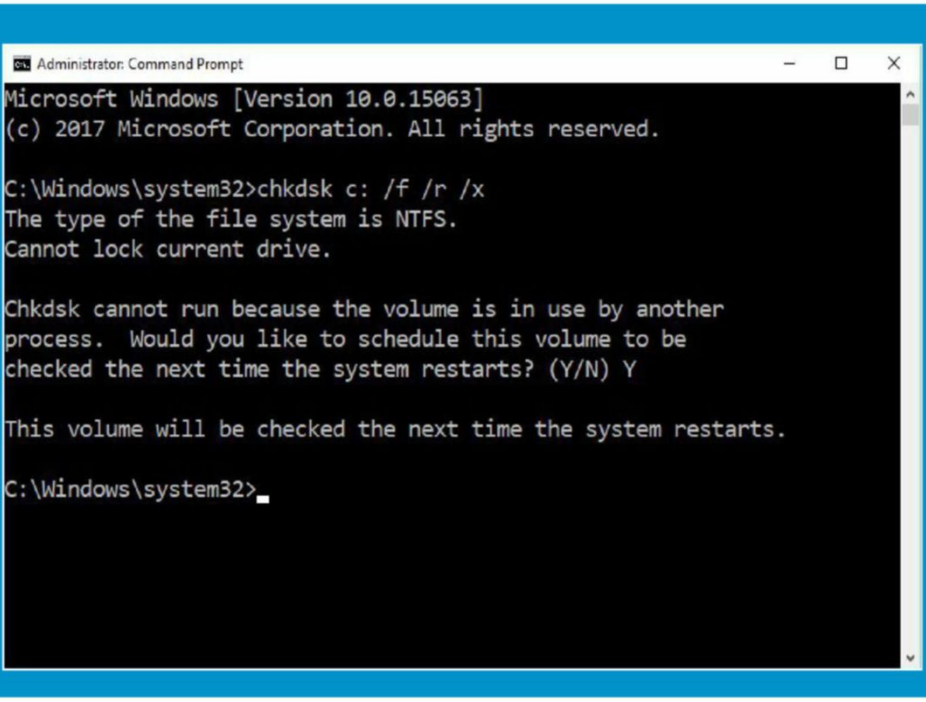
2. TEST AND REVIEW
Windows restarts as normal with one difference: When the desktop appears, you'll see a countdown timer appear in the bottom-right corner. When complete, a stopwatch showing your boot time is displayed. When the summary screen appears, click "Know more" to review the result in detail.



3. DETAILED ANALYSIS
BootRacer splits the results into four parts—see the main text above for a detailed explanation of each. BootRacer performs the same test each time you restart Windows, so restart again to repeat the test at least once to get more results to compare. Click "History" to see the trend over time.

HOW FAST BOOT WORKS

When you switch on a Windows 7 machine, it always starts from a "cold boot," which has to load Windows from scratch. With the advent of modern PC hardware and the launch of Windows 8.1 (and now Windows 10), supported PCs can be instructed to switch on Fast Boot instead. This uses "hybrid shutdown," a feature that effectively hibernates your PC, rather than shutting it down completely, by storing the contents of memory in a special file, called hiberfil.sys. When starting back up, the file is loaded back into memory—a much quicker process than starting Windows completely from scratch.



```
Microsoft Windows [Version 10.0.15063]
(c) 2017 Microsoft Corporation. All rights reserved.

C:\Windows\system32>chkdsk c: /f /r /x
The type of the file system is NTFS.
Cannot lock current drive.

Chkdsk cannot run because the volume is in use by another
process.  Would you like to schedule this volume to be
checked the next time the system restarts? (Y/N) Y

This volume will be checked the next time the system restarts.

C:\Windows\system32>_
```

unavailable," check the box, and click "Save changes." Should you need to access the UEFI settings going forward, go to "Settings → Update and recovery." Click "Restart now" under "Advanced startup," then select "Troubleshoot → Advanced Options → UEFI Firmware Settings."

Speed Up Windows Boot

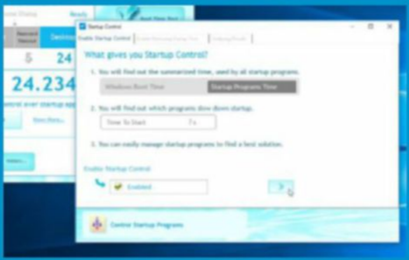
The Windows Boot section refers to the time your PC takes to get to the login screen. This is determined by your version of Windows as well as the speed of your drive—under 10 seconds on a fast SSD, for example—and the drive's condition.

If the time has got noticeably longer (minutes rather than seconds), check the condition of the drive. To do that, open a Command Prompt window with admin privileges—Windows 8.1 and 10 users can choose "Command Prompt (admin)" after pressing Win-X—then type the following, and hit Enter:

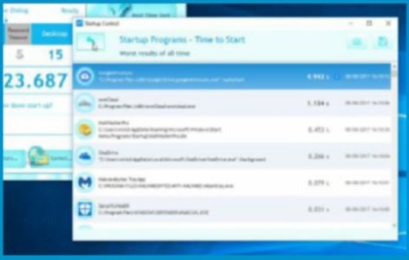
```
chkdsk c: /f /r /x
```

You need to reboot to run Disk Check. Be patient—it may take some time to complete, and appear to be stuck at certain points. If errors are found and fixed, you should find that Windows now boots more quickly.

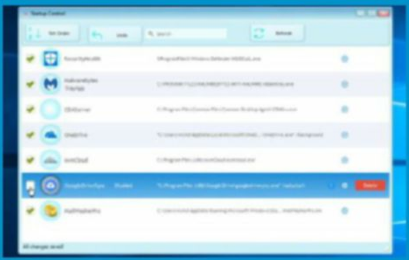
If you're running Windows 7 on a non-SSD drive, click "Start → All Programs → Accessories → System Tools → Disk Defragmenter" to analyze and—if necessary—defragment the drive. Again, if defragmentation is required, you should find performance improves.



4. TAKE CONTROL
BootRacer can be used to monitor (and control) individual startup programs and processes. Click "Startup Control," then click the button next to "Disabled" to enable it. Click "Next," leave the "Enabled" box checked to measure program start times, and click "Restart your PC and Analyze Results."



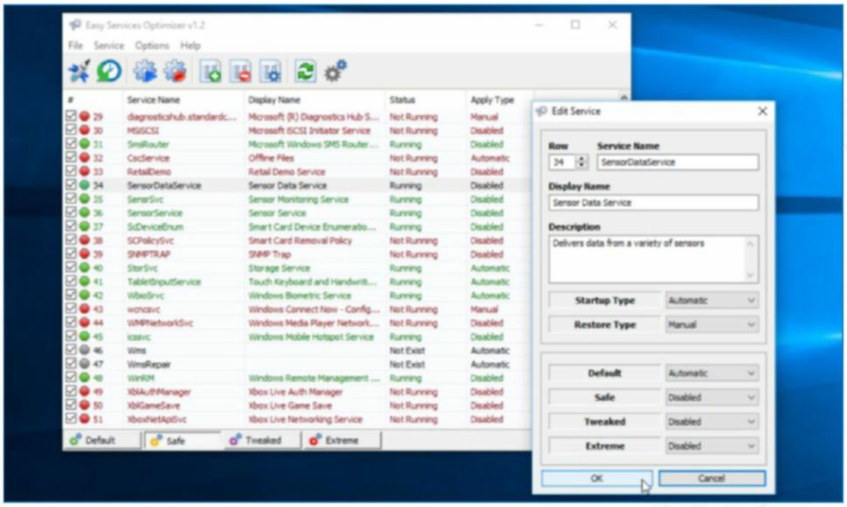
5. MONITOR APPS
Now, when Windows reboots, startup apps are paused until the desktop has finished loading, then each one is timed. Keep an eye out for programs that take much longer than others to complete loading—click "Which programs slow down startup?" to analyze the results in greater detail.



6. MANAGE STARTUP
Click "Startup Control," and you can disable (clear the check) or even delete startup items like other apps, such as CCleaner. Click "Set Order," and you can even change the order in which startup programs are run, ensuring important apps launch before others. Click "Finish Reordering" when you're done.

TUNE UP WINDOWS

Discover more tips, tricks, and tweaks that you can use in Windows to deliver even more speed improvements to your machine



#	Service Name	Display Name	Status	Apply Type
☑ ● 29	diagnosticshub.standardc...	Microsoft (R) Diagnostics Hub S...	Not Running	Manual
☑ ● 30	MSiSCSI	Microsoft iSCSI Initiator Service	Not Running	Disabled
☑ ● 31	SmsRouter	Microsoft Windows SMS Router...	Running	Disabled
☑ ● 32	CscService	Offline Files	Not Running	Automatic
☑ ● 33	RetailDemo	Retail Demo Service	Not Running	Disabled
☑ ● 34	SensorDataService	Sensor Data Service	Running	Disabled
☑ ● 35	SensrSvc	Sensor Monitoring Service	Running	Disabled
☑ ● 36	SensorService	Sensor Service	Running	Disabled
☑ ● 37	ScDeviceEnum	Smart Card Device Enumeratio...	Running	Disabled
☑ ● 38	SCPolicySvc	Smart Card Removal Policy	Not Running	Disabled
☑ ● 39	SNMPTRAP	SNMP Trap	Not Running	Disabled
☑ ● 40	StorSvc	Storage Service	Running	Automatic
☑ ● 41	TabletInputService	Touch Keyboard and Handwrit...	Running	Automatic
☑ ● 42	WbioSrvc	Windows Biometric Service	Running	Automatic
☑ ● 43	wcncsvc	Windows Connect Now - Config...	Not Running	Manual
☑ ● 44	WMPNetworkSvc	Windows Media Player Network...	Not Running	Disabled
☑ ● 45	icssvc	Windows Mobile Hotspot Service	Running	Disabled
☑ ● 46	Wms		Not Exist	Automatic
☑ ● 47	WmsRepair		Not Exist	Automatic
☑ ● 48	WinRM	Windows Remote Management ...	Running	Disabled
☑ ● 49	XblAuthManager	Xbox Live Auth Manager	Not Running	Disabled
☑ ● 50	XblGameSave	Xbox Live Game Save	Not Running	Disabled
☑ ● 51	XboxNetApiSvc	Xbox Live Networking Service	Not Running	Disabled

Row: 34
Service Name: SensorDataService
Display Name: Sensor Data Service
Description: Delivers data from a variety of sensors
Startup Type: Automatic
Restore Type: Manual
Default: Automatic
Safe: Disabled
Tweaked: Disabled
Extreme: Disabled

Shut down unused Services to free up more system resources and speed up your PC.

You've cleaned up your PC, but there's still lots of room for improvement. If it's still struggling on a day-to-day basis—particularly if it has 2GB of RAM or less—it's worth exploring additional ways to free up more resources by optimizing which services (low-level processes) are running in the background.

Doing this by hand is tricky and time-consuming, which is where Easy Services Optimizer (www.sordum.org/?p=8637) comes in. This makes it easy to disable a range of services safely to recover the resources you need. Once downloaded, you can quickly tweak your system one of four ways: Default (your existing setup); Safe (a good choice for most); Tweaked; and Extreme. The higher up you go, the more likely it is you'll lose functionality, such as support for printers or Bluetooth devices. If an option doesn't work, roll back to Default.

If you'd rather temporarily suspend resources while running a specific app—a game, say—try JetBoost (www.bluesprig.com/jetboost.html) instead. Once installed, launch the program, and click the big blue button to shut down services. Run your app, then after closing it, click "Restore" to put things back the way they were.

Advanced users can click "Customize" to add custom processes, services (typically non-Windows services, but avoid key ones such as security software), and "other," which includes ensuring your power settings are set to high performance.

Tune Up Search

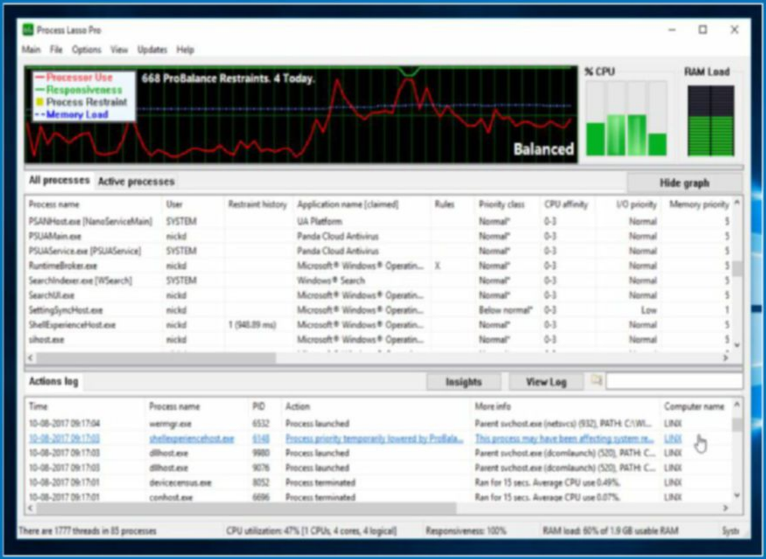
If you're not averse to keeping documents and other files outside your key user folders,

TAME ROGUE PROGRAMS

If your PC occasionally—or even frequently—finds itself grinding to a halt before mysteriously coming back to life again, it's likely that a rogue process or program is attempting to claim more system resources than are available. Again, it's a problem that affects older and slower machines, and the solution lies in a program called Process Lasso (https://bitsum.com).

This app runs in the background and offers several performance benefits, the key one of which is ProBalance. This keeps an eye out for those processes attempting to grind your system to a halt. When Process Lasso spots one, it immediately reduces that process's priority level, to prevent it from stealing too many system resources, so keeps your PC running smoothly as a result.

Be sure to download either the 32-bit or 64-bit version, according to your system type—older and low-memory PCs tend to be running 32-bit Windows, but confirm this by pressing Win-Pause/Break. The free version of Process Lasso is all you need, and because everything is done automatically, you can leave this handy tool to its own devices once installed.



668 ProBalance Restraints. 4 Today.

Process name	User	Restraint history	Application name [claimed]	Rules	Priority class	CPU affinity	I/O priority	Memory priority
PSANHost.exe [NanoServiceMain]	SYSTEM		UA Platform		Normal*	0-3	Normal	5
PSUAMain.exe	nickd		Panda Cloud Antivirus		Normal*	0-3	Normal	5
PSUAService.exe [PSUAService]	SYSTEM		Panda Cloud Antivirus		Normal*	0-3	Normal	5
RuntimeBroker.exe	nickd		Microsoft® Windows® Operatin...	X	Normal*	0-3	Normal	5
SearchIndexer.exe [WSearch]	SYSTEM		Windows® Search		Normal*	0-3	Normal	5
SearchUI.exe	nickd		Microsoft® Windows® Operatin...		Normal*	0-3	Normal	5
SettingSyncHost.exe	nickd		Microsoft® Windows® Operatin...		Below normal*	0-3	Low	1
ShellExperienceHost.exe	nickd	1 (948.09 ms)	Microsoft® Windows® Operatin...		Normal*	0-3	Normal	5
sihost.exe	nickd		Microsoft® Windows® Operatin...		Normal*	0-3	Normal	5

Time	Process name	PID	Action	More info	Computer name
10-08-2017 09:17:04	wermgr.exe	6532	Process launched	Parent svchost.exe (netsvcs) (932), PATH: C:\Wi...	LINX
10-08-2017 09:17:03	shellexperiencehost.exe	6148	Process priority temporarily lowered by ProBala...	This process may have been affecting system re...	LINX
10-08-2017 09:17:03	dllhost.exe	9980	Process launched	Parent svchost.exe (dcomlaunch) (520), PATH: C...	LINX
10-08-2017 09:17:03	dllhost.exe	9076	Process launched	Parent svchost.exe (dcomlaunch) (520), PATH: C...	LINX
10-08-2017 09:17:01	devicecensus.exe	8052	Process terminated	Ran for 15 secs. Average CPU use 0.49%.	LINX
10-08-2017 09:17:01	conhost.exe	6696	Process terminated	Ran for 15 secs. Average CPU use 0.07%.	LINX

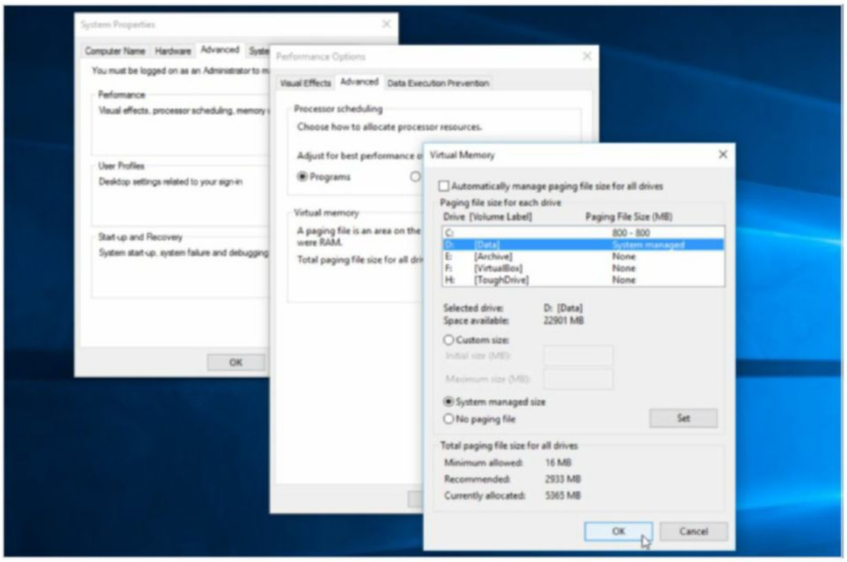
There are 1777 threads in 85 processes CPU utilization: 47% [1 CPUs, 4 cores, 4 logical] Responsiveness: 100% RAM load: 60% of 1.9 GB usable RAM chances are Windows takes a long time to find them when you perform a search—if they're found at all. Let Windows add these locations to its index, and future searches will be much quicker. Open File Explorer in Windows 8.1 or Windows 10, and click inside the "Search" box to open the context-sensitive "Search" tab on the Ribbon. Click "Advanced options," and choose "Change indexed locations." Windows 7 users should type "indexing" into the "Start" menu's search box, and click "Indexing Options."

From here, click "Modify" to add the folders containing your files to the index—also consider removing those locations you don't need indexed, to keep things streamlined. Once done, Windows takes some time to index the new locations fully—this is much quicker on SSDs, obviously.

If you've partitioned your drive, move your search index off your Windows system drive, and you'll be able to easily restore it after reinstalling Windows in the future. To do this, click "Advanced," followed by "Select New" under "Index location," to choose another drive or partition to put it.

Optimize Memory Settings

The following tweaks aren't necessary if your PC is packed with RAM or you're running an SSD, but they help PCs with 2GB or less running 32-bit Windows on a regular hard drive. You need a USB 2.0 or better flash drive with 4GB of free space, enabling you to use the spare capacity on larger drives for other purposes. Windows should be able to automatically detect when you've plugged it in, and offer to use all or some of it for ReadyBoost. If not, open File Explorer, right-click the USB drive, and choose "Properties → ReadyBoost tab."



☐ Automatically manage paging file size for all drives

Paging file size for each drive

Drive [Volume Label]	Paging File Size (MB)
C:	800 - 800
D: [Data]	System managed
E: [Archive]	None
F: [VirtualBox]	None
H: [ToughDrive]	None

Selected drive: D: [Data]
Space available: 22901 MB

○ Custom size:
● System managed size
○ No paging file

Total paging file size for all drives
Minimum allowed: 16 MB
Recommended: 2933 MB
Currently allocated: 5365 MB

If you have two internal drives, spread virtual memory across them to boost performance.

The second tweak requires that your PC has two internal hard drives—both non-SSD. It enables you to move your paging file—which Windows uses for virtual memory—to the second drive, which can also give overall performance a boost. Press Win-Pause/Break, click "Advanced system settings," switch to the "Performance" tab, and click "Settings." Switch to the "Advanced" tab, and click "Change."

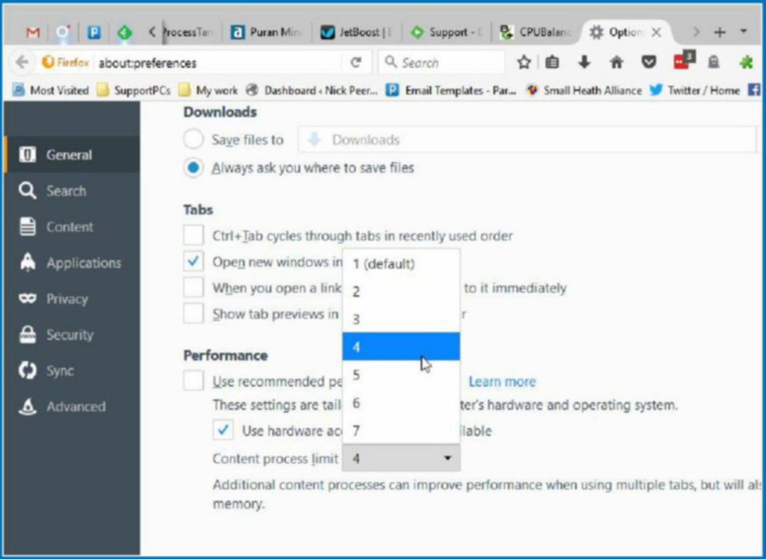
Uncheck "Automatically manage paging file size for all drives," then select your current Windows drive (usually drive C). Choose "Custom," and enter "800" into both the "Initial" and "Maximum Size" boxes, before clicking "Set." This 800MB file is required to enable Windows to boot. Now select your second drive (or—if it's been partitioned—the least-used partition on that drive), and choose "System managed size." Click "Set" again, then click "OK" three times, and reboot. Once done, return to this screen to verify the correct settings are in place (800MB for drive C; and "System managed" for your second drive). This should lead to improvements in your PC's performance. ⏻

SPEED UP YOUR BROWSER

If your web browser is groaning under the weight of all those open tabs, you might be able to improve performance without having to close them all. If you're a Firefox user with lots of RAM, open "Settings → General," and uncheck "Use recommended performance settings." Then, if it's not grayed out, up the "Content process limit" to four or even higher, to see whether it helps.

Next, there are a few browser-related efficiency tips you can try to speed things up generally. First, enable your browser's Bookmarks bar, giving you one-click access to your favorite websites. Also, right-click frequently used tabs, and look for a "Pin Tab" option, to make them permanently available.

Speed up logging into websites—and make them more secure at the same time—using either the LastPass (www.lastpass.com) or KeePass (www.keepass.info) password managers. Finally, make better use of search engine timesavers—Google users can perform quick conversions direct from the search bar ("$5 to CAD"), and search a specific website's content by prefixing the search terms with "site:pcgamer.com," for example.



about:preferences

○ Save files to Downloads
● Always ask you where to save files

☐ Ctrl+Tab cycles through tabs in recently used order
☑ Open new windows in
☐ When you open a link ... to it immediately
☐ Show tab previews in

☐ Use recommended pe
These settings are tail ...ter's hardware and operating system.
☑ Use hardware ac ...ilable
Content process limit 4

Additional content processes can improve performance when using multiple tabs, but will al memory.

LET THE AMAZON ECHO CHANGE YOUR LIFE TODAY

Discover everything you need to know to get the most from Amazon's voice-activated speaker and its built-in digital assistant, Alexa

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Future
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Master essential commands & more
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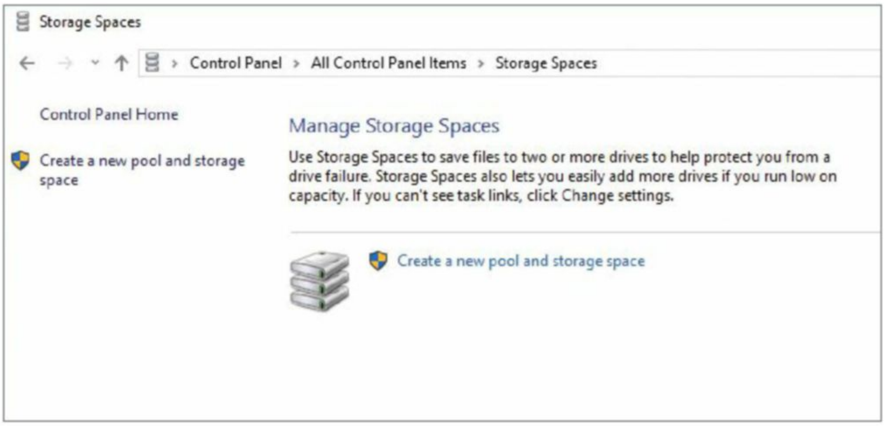
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH



Storage Spaces

← → ˅ ↑ > Control Panel > All Control Panel Items > Storage Spaces

Control Panel Home

Create a new pool and storage space

Manage Storage Spaces

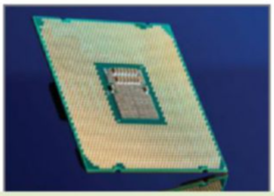
Use Storage Spaces to save files to two or more drives to help protect you from a drive failure. Storage Spaces also lets you easily add more drives if you run low on capacity. If you can't see task links, click Change settings.

Create a new pool and storage space

SET UP STORAGE SPACES IN WINDOWS 10

We've been messing around with a plethora of drive setups recently. Whether that's been with Dream Machine 2017, or our own rendering rigs, more secure drive configurations have begun to be a vital part of our systems, and will continue to be so going forward. Luckily, with Windows 10, they're much easier to set up. All you need to do is click the "Start" menu, type "manage storage spaces," select the drives you want to use, hit "create pool" at the bottom, then choose your parity, and you're good to go.

MAKE – USE – CREATE



64
Push Intel's Skylake-X CPUs to the limit

66
Secure network devices with a managed switch

70
Step-by-step, how to build a Coffee Lake future-proofed rig

ZAK STOREY
DEPUTY EDITOR

MAKING INTEL BETTER

I've spent a good while trying AMD's Ryzen architecture at home, and although it's a fantastic little chip, the overclocking experience is incredibly limited, and it hasn't quite satisfied my progressive power itch.

Recently, Intel loaned us two Core i9-7900Xs, and I'm tempted to take one of those for a personal upgrade. The thing is, X299 has issues involving overclocking, too. The first is to do with the VRMs (voltage regulation modules) throttling the processor once they hit 107 C. That's a fairly easy fix—the answer is to invest in a liquid-cooled monoblock that cools both the processor and the VRMs.

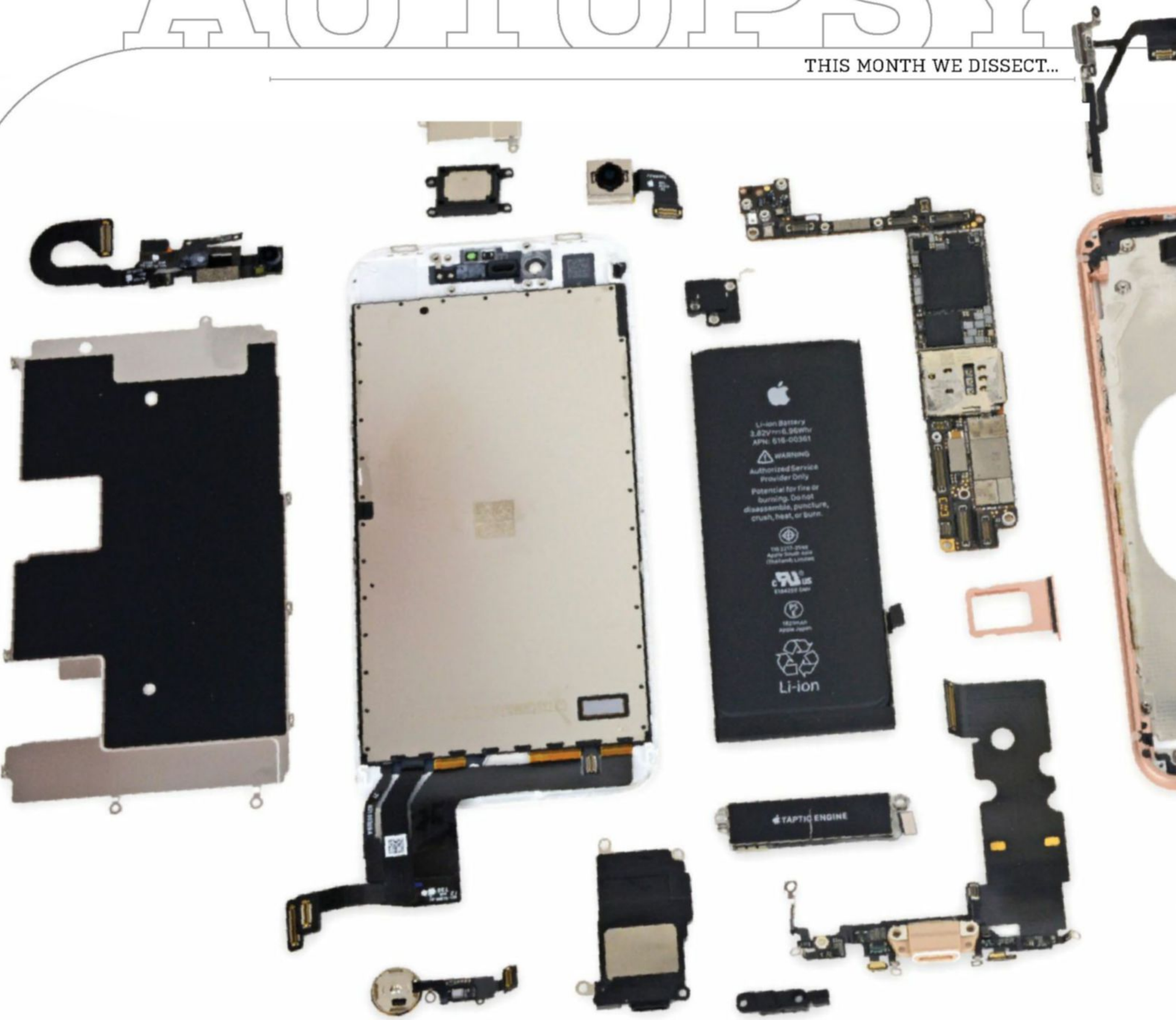
Far more terrifying to solve is the fact that Intel refuses to solder the IHS (heat spreader) on to the CPU die, instead using cheap thermal paste to transfer heat from the die to the IHS. The solution would be to delid the CPU, a risky process that typically requires you to use a razor blade to separate the IHS from the CPU and PCB. So, we got in touch with Der8auer, the world famous overclocker, to see whether he could loan us one of his Delid Die Mate Xs. It's a neat little device, that removes the IHS safely. It's then up to us to clean off the glue, apply liquid metal thermal paste between the CPU die and the IHS, then reglue the IHS back down for far lower temperatures. Still terrifying, but in the hunt for better thermals, overclocks, and more, we simply have to give it a try.

↘ submit your How To project idea to: comments@maximumpc.com

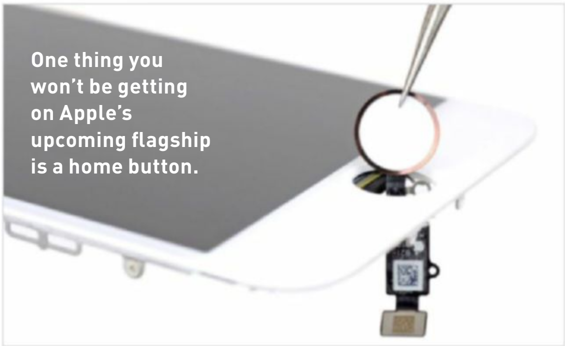
IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...



The iPhone 8 has a smaller battery than its iPhone 7 predecessor.



One thing you won't be getting on Apple's upcoming flagship is a home button.

Apple's iPhone 8

BACKGROUND

Apple's skipped its iPhone "S" update, so we skipped ahead a couple timezones. We went to Circuitwise headquarters, in Sydney, Australia, for our iPhone 8 teardown. Time to find out whether Apple's merely playing numerical catch-up to Samsung's Galaxy S8 line, or if glass backing and wireless charging warrant skipping ahead a grade.

MAJOR TECH SPECS

- A11 Bionic chip, with embedded M11 motion coprocessor
- 64GB or 256GB onboard storage capacity
- 4.7-inch IPS multitouch 1334x750 (326 ppi) Retina HD display
- 12MP camera with f/1.8 aperture, optical image stabilization, and 5x digital zoom
- 7MP FaceTime HD camera with f/2.2 aperture and 1080p HD recording capability
- Support for fast-charge and Qi wireless charging
- 802.11a/b/g/n/ac Wi-Fi, MIMO, Bluetooth 5.0, and NFC

KEY FINDINGS

- Features include a solid-state home "button," with Touch ID fingerprint sensor, and a (still) IPS display, similar to the one in the iPhone 7 (but now featuring True Tone). On the back, we spy the snazzy new glass backing, with its seven-layer color finish. Apple assures us that it is reinforced with "an internal laser-welded steel and copper structure," but time and durability tests will tell if this phone will suffer from a snap, crackle, pop—or another Bendgate.

- As we crack open the display, we are greeted by the display cable bracket, but instead of the cursed tri-point screws, we're met by friendly Phillips #000 screws! We decouple a few cables—battery, display, and home button—and the display is free! We note a lack of gaskets on the display's pentalobe tabs, previously seen in the iPhone 7. However, both the iPhone 7 and 8 have an IP67 water resistance rating.

- A new Lightning port bracket seems to reinforce the new peach-colored port and trap the Taptic engine. Up until now, we've plugged along with our Phillips screwdriver—but in removing this bracket, we encountered our first tri-point screw. We suspect the colored Lightning port could be made of a heat-transferring plastic to allow for safer fast-charging.

- We take a stab at separating the rear glass, but after a lot of heat and wetwork, we've instead shivved our way under the reinforcement panel. After more arduous stabbing, we get the seven-layer burrito glass sandwich off the midframe. This isn't what we thought Apple meant when it said the glass was stronger. The process left the backing plate a bit bent.

- Repairability Score: 6 out of 10 (10 is easiest to repair). The two most commonly replaced components, display and battery, remain straightforward to access with the proper knowledge and tools. Wireless charging means less strain on your Lightning port, a common point of failure. Water and dust seals complicate repair, but make the need for difficult liquid-damage repairs less likely. The battery connector sports common Phillips/JIS fasteners—but you still need up to four different driver types for many repairs. The durability of the glass back remains to be seen—but replacements are likely to be very difficult. The iPhone's lower components, once readily removed, now lie trapped under a fussy combination of brackets and delicately folded flex cables.

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

Push Intel's Skylake-X Processors to the Limit

YOU'LL NEED THIS

UNLOCKED INTEL CPU
Any X299 CPU or K series chip.

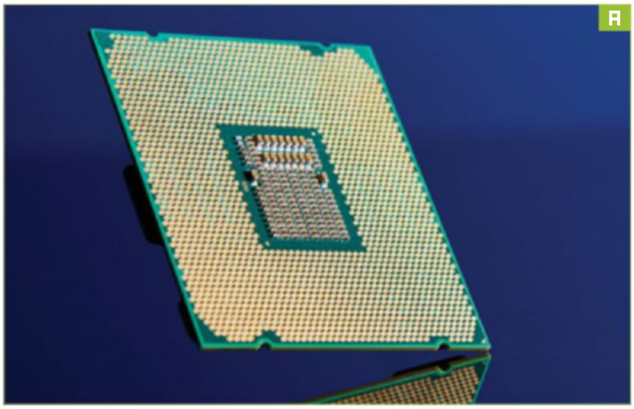
ASUS X299 MOBO
And don't forget cooling .

SUITABLE PSU
Check https://pcpartpicker.com/list/ for a usage estimate.

IF YOU'VE READ OUR REVIEW of the Core i9-7980XE on page 76 [**Image A**], you'll know it's one monster of a processor. This thing is a beast: 18 cores and 36 threads of pure 14nm fury made manifest. Assuming you're willing to invest the $2,000 needed to home this heady chip, or eager to splash the cash on any of the prestigious Skylake-X processors, if you want to get the most out of your new CPU, the only option is to overclock it.

It's fair to say that Intel hasn't had the best of times when it comes to overclocking its last two generations of chips. Both the mainstream Z270 and HEDT X299 chipsets have been fraught with everything from temperature issues to VRM throttling, and more. There's plenty of aftermarket solutions to these conundrums, though, from delidding and replacing the stock thermal paste on your sexy slither of silicon, to using a more substantial cooling solution to chill the VRMs.

However, that's not to say these chips can't clock, because, boy, they really can. And with the Core i9-7980XE clocking a phenomenal 30 percent improvement in both single and multicore performance in render-heavy workloads, the temptation to amp up the voltages is arguably greater than ever. So, how do you get the most out of your chip? We're here to show you. –**ZAK STOREY**

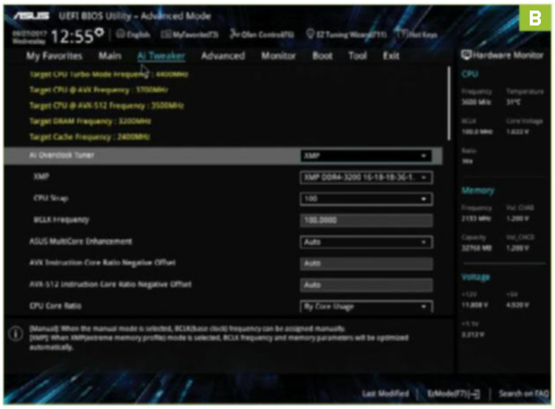


1 POWER AND HEAT

When you overclock, applying more voltage and ramping up the multiplier inevitably does two things to your rig: it introduces more heat to your system, and draws more power from the wall. You need to make sure you have a power supply that has around 20 to 30 percent more headroom than you're currently using, and ensure that your cooling solution is suitable for the task. We recommend that your chassis has, as the absolute minimum, two well-ventilated intake fans, one exhaust fan, and a suitably powerful CPU heatsink. You can achieve this with some of the chunkier air coolers, but you'll get better results by investing in an AIO (all-in-one) liquid cooler. Any processor with fewer than six threads needs a 120mm AIO, while we recommend a 240mm AIO for 6 to 16 threads, and for anything higher than that, you need a 280mm AIO, or a full custom loop.

2 PRIME FOR PRELIMINARY BENCHMARKS

We need to run some preliminary benchmarks to find out how well our system handles at stock. To do this, we head to the BIOS and activate the Extreme Memory Profile (or XMP). Restart your system, mash the Delete key, and enter Asus's UEFI BIOS. Then, hit F7 to go into Advanced Mode, and select the "Ai Tweaker" menu at the top [**Image B**]. Go down to "Ai Overclock Tuner," and select "XMP." Hit F10, save, and go back to the desktop.



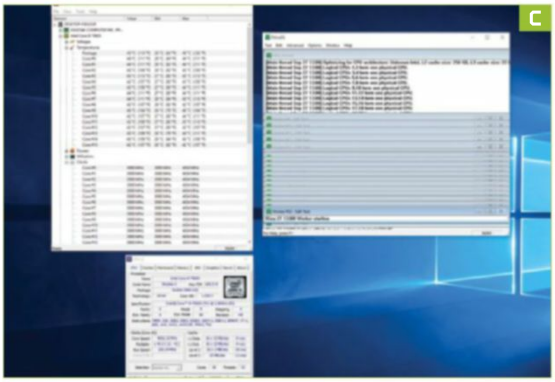
Target CPU Turbo-Mode Frequency : 4400MHz
Target CPU @ AVX Frequency : 3700MHz
Target CPU @ AVX-512 Frequency : 3500MHz
Target DRAM Frequency : 3200MHz
Target Cache Frequency : 2400MHz

Ai Overclock Tuner: XMP
XMP: XMP DDR4-3200 16-18-18-36-1.
CPU Strap: 100
BCLK Frequency: 100.0000
ASUS MultiCore Enhancement: Auto
AVX Instruction Core Ratio Negative Offset: Auto
AVX-512 Instruction Core Ratio Negative Offset: Auto
CPU Core Ratio: By Core Usage

[Manual]: When the manual mode is selected, BCLK(base clock) frequency can be assigned manually.
[XMP]: When XMP(extreme memory profile) mode is selected, BCLK frequency and memory parameters will be optimized automatically.

3 GRAB THE SOFTWARE

Download HWMonitor, CPU-Z (both available from www.cpuid.com), Prime95 (www.mersenne.org), and Cinebench R15 (www.maxon.net). In Prime 95, hit "Just Stress Testing," then when the "Run a Torture Test" window opens, hit "OK" [**Image C**]. This runs a stress test on your processor by forcing it to search for Mersenne prime numbers. Run this for around five minutes, then click the "Test" menu, and hit "Stop." Bring up the HWMonitor

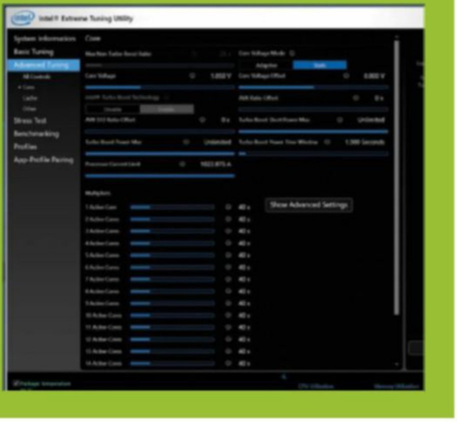


INTEL'S EXTREME TUNING UTILITY

You can actually do a fair amount of this from the desktop, using Intel's Extreme Tuning Utility (XTU). It's a neat piece of freeware developed by Intel, which enables you to adjust a variety of settings from the desktop. You can adjust the multiplier, base clock, and voltages, and apply these settings direct from the desktop. You still face similar instability issues once you push the multiplier higher, but it does save time, as you don't need to restart your rig every time you apply new settings.

The only major downsides are to do with how you apply the core voltage. By default, Intel's XTU sets it to "Adaptive" (think "Auto")—to change this, you have to adjust the "Core Voltage" figure to the right (we recommend 1.0V for any Skylake-X chip), then change the "Core Voltage Mode" from "Adaptive" to "Static," and adjust the "Core Voltage Offset" by the increments we mention in the main tutorial.

It even detects whether you've made any changes in BIOS and applies them directly to the same settings on desktop, and includes its own stress tests and integrated benchmarks, along with a plethora of monitoring tools.



window, and look for the subheading with your processor's model name in it. Take note of the maximum temperature of the overall package, and the highest core clock achieved across all cores.

4 CHANGE THE MULTIPLIER

Now, open CPU-Z and Cinebench R15. In the latter, run the CPU test, and note down the score when it's finished. While it's running, take a quick look at the Core Voltage, displayed by CPU-Z. Head back into the BIOS, and straight back to the "Ai Tweaker" section. Find the drop-down menu that reads "CPU Core Ratio." By default, this should be set to "Auto," so change it to "Sync All Cores." Now to calculate your multiplier – it's the max turbo frequency across all cores in GHz multiplied by 1,000 (conversion to MHz), and divided by 100 (frequency of the base clock). Once you know this, you can then change the "All-Core Ratio Limit" from "Auto" to a suitable multiplier of your choice. We recommend going up by one or two at a time.

5 RETEST

Once you've changed the multiplier, scroll down to "CPU Core Voltage," change it to "Manual," then set the override voltage to the one you noted down earlier from CPU-Z during your test. We're going to start out using 1.0V, with a multiplier of 36 [**Image D**]. Then hit F10, save, and exit, log in to the desktop, and run the same tests we performed earlier to see whether your overclock, with the new multiplier, is stable.

6 KEEP GOING

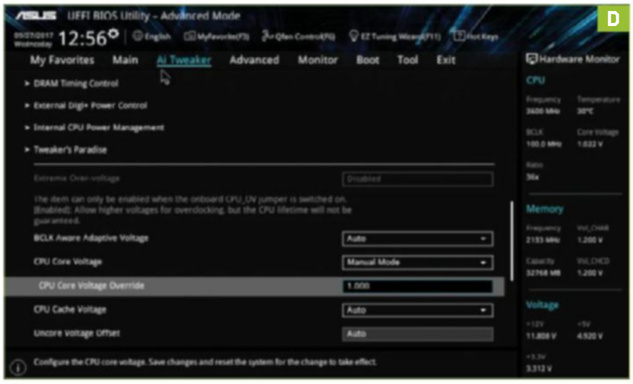
Keep increasing the multiplier, until you reach instability and blue screen. At this point, you need to head back to the BIOS and increase the core voltage. It's extremely important not to overload the chip with too much voltage—we suggest increasing the VCore by 0.05V at a time, especially on the higher end Skylake X chips. Then head back to the desktop to see whether your chip is stable in the benchmarks. You should start to see an increase in both power draw and temperature at this point. Then it's simply a case of increasing the voltage and multiplier until you can no longer achieve a stable overclock, then dial back the multiplier by one or two, and you're all set.

7 ADDITIONAL TWEAKS

There are a few extra things we can do to improve stability and push our overclock further, the first of which is altering the VRM profile. Back in the "Ai Tweaker" menu, go into the "External Digi+ Power Control" section. Once there, find the setting labeled "VRM Spread Spectrum," and disable it. Then, find the "CPU Power Phase Control" setting, and change that from "Auto" to "Extreme"—this should help balance the current across the VRMs, ensuring a higher overclock. Finally, if you want to go all-out, go back to "Ai Tweaker," then to "Intel CPU Power Management," and disable "Intel's Speedstep technology" [**Image E**].

8 MEASURE YOUR GAINS

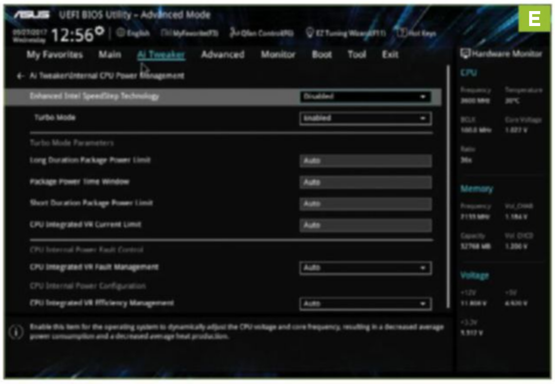
That ensures you get the absolute most out of your overclock attempts with Skylake-X. Then you can go back to desktop, and run Cinebench R15 again, to see just how much performance you've gained. ⏻


D

UEFI BIOS Utility – Advanced Mode

BCLK Aware Adaptive Voltage: Auto
CPU Core Voltage: Manual Mode
CPU Core Voltage Override: 1.000
CPU Cache Voltage: Auto
Uncore Voltage Offset: Auto

Configure the CPU core voltage. Save changes and reset the system for the change to take effect.


E

UEFI BIOS Utility – Advanced Mode

Ai Tweaker\Internal CPU Power Management
Enhanced Intel SpeedStep Technology: Disabled
Turbo Mode: Enabled
Long Duration Package Power Limit: Auto
Package Power Time Window: Auto
Short Duration Package Power Limit: Auto
CPU Integrated VR Current Limit: Auto
CPU Integrated VR Fault Management: Auto
CPU Integrated VR Efficiency Management: Auto

Secure Your Network Devices

YOU'LL NEED THIS

MANAGED SWITCH OR ROUTER WITH VLAN SUPPORT

We're using TP-Link's TL-SG108E switch, which you can pick up for around $30-35 online, and the Archer VR900 router ($105).

EVER WANTED TO SPLIT YOUR NETWORK in two (or more)? Perhaps you want to divide up an Internet connection in a shared household, giving everyone their own private network, or maybe you're worried about certain devices from a security point of view, and would like to isolate them from the rest of your network. Perhaps you're interested in dividing between home and work, or have heard you might be able to improve overall network performance by splitting off those devices that often bring things grinding to a halt.

The potential solution to all these problems is to set up a VLAN (virtual LAN). VLAN-capable hardware enables you to split a single physical network into two or more separate entities. They share your Internet connection, but nothing else. Many mid to high-end consumer routers offer VLAN capabilities, while managed (or "smart") switches offer varying levels of VLAN support, too.

If your router doesn't seem to support VLANs, visit www.dd-wrt.com to see if it supports the open-source DD-WRT firmware. If it does, replacing your stock firmware with this—a task we don't recommend for less experienced users (you could render your router unusable)—can give you VLAN capabilities similar to those outlined below. **–NICK PEERS**

1 PORT-BASED VLANS

Routers that support VLANs enable you to segment your network by assigning separate VLANs to individual Ethernet ports. Everything plugged into that port (including any switch you connect) becomes a member of that VLAN. Some routers—including the TP-Link Archer VR900 we're featuring here [**Image A**]—can also assign wireless networks to specific VLANs.

2 CONFIGURE YOUR ROUTER

Once you've consulted its manual to discover how to set up port-based VLANs, log into your router's configuration utility via your web browser. Archer VR900 users should navigate to "Advanced → Network → LAN Settings → Interface Grouping" [**Image B**]. Click "Add," give your group a name, and select which ports and wireless networks will become part of the new VLAN. Make sure "Enable Group Isolation" is checked, and click "OK"—this ensures the VR900 bans any cross-network traffic.

» Each new VLAN is assigned a different subnet. To see what these settings now are, you need to go back to "LAN Settings." Any devices connected to this VLAN that don't use DHCP for their network settings need to be manually configured to access the new subnet.

3 EXTENDED VLAN OPTIONS

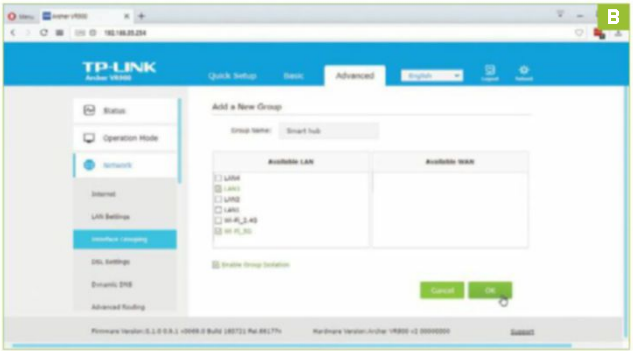
Managed switches, such as TP-Link's TL-SG108E, also come with support for VLANs, enabling you to set up VLANs for different locations in your home using smart switches as the central point—particularly handy in a powerline network, where your switch can't be directly plugged into the router.

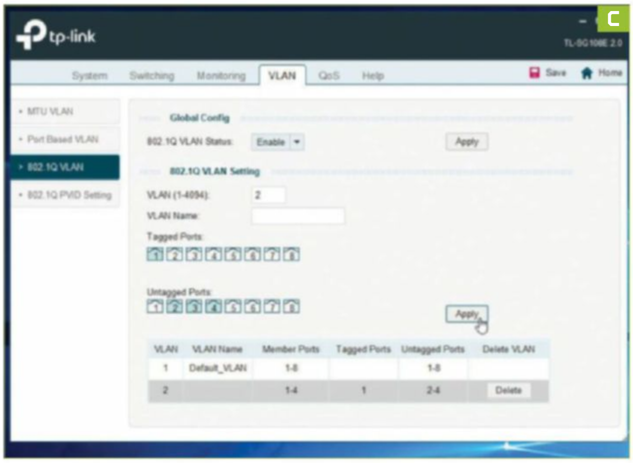
» Log in to your SG108E's Easy Smart Configuration utility. Switch to the "VLAN" tab, and you'll see several options. "MTU VLAN" is a rough and ready option, enabling you to quickly isolate all the ports from each other—but your devices remain visible and accessible to any computer not connected via the switch. The best option by far is "802.1Q VLAN," which works by tagging network traffic in each VLAN with the VLAN ID, enabling it to be filtered accordingly.

4 GROUP DEVICES TOGETHER

Select "802.1Q VLAN," set its status to "Enable," and click "Apply." You'll see the "VLAN (1-4094)" field, inviting you to create a numbered VLAN (numbers 2–4094 are available).

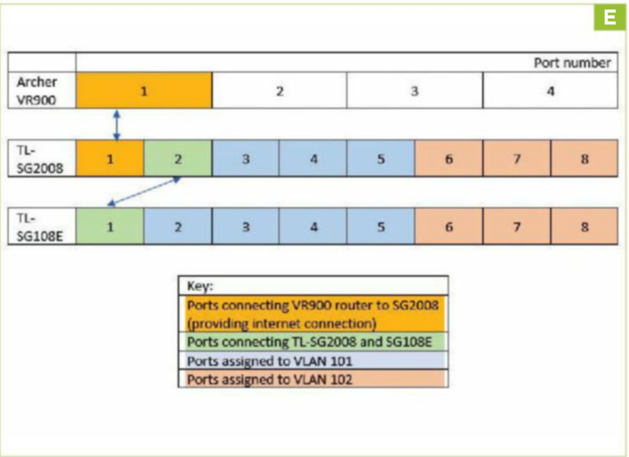
» The "VLAN Name" field is optional. Assuming your switch is connected to the rest of your network via port 1, click "1" under "Tagged Ports." The port can be a member of multiple VLANs, enabling you to provide Internet access





802.1Q VLAN Status: Enable
VLAN (1-4094): 2
VLAN Name:
Tagged Ports: 1 2 3 4 5 6 7 8
Untagged Ports: 1 2 3 4 5 6 7 8

VLAN	VLAN Name	Member Ports	Tagged Ports	Untagged Ports	Delete VLAN
1	Default_VLAN	1-8		1-8	
2		1-4	1	2-4	Delete



	Port number							
Archer VR900	1	2	3	4				
TL-SG2008	1	2	3	4	5	6	7	8
TL-SG108E	1	2	3	4	5	6	7	8

Key:
Ports connecting VR900 router to SG2008 (providing internet connection)
Ports connecting TL-SG2008 and SG108E
Ports assigned to VLAN 101
Ports assigned to VLAN 102

to all the VLANs you create. Next, select the ports you wish to isolate from the rest of your network, by clicking their numbers in turn under "Untagged Ports." Click "Apply." Now select "802.1Q PVID Setting" in the left-hand menu. Type the VLAN ID you set up into the "PVID" field, then check all the untagged ports you're isolating, and click "Apply" [**Image C**].

» The effect should be immediate. Try pinging any of the devices on this switch from your PC via a command prompt, and you should get no response, or a "destination unreachable" error [**Image D**]. Congratulations—you've just isolated these devices from the rest of your network; they should still have Internet access, enabling you to remotely connect to smart home equipment, for example. Add more VLANs to split devices further.

5 EXTEND VLAN

If you have two or more managed switches, you can extend your VLANs from one switch to the next, which enables you to group devices together into the same VLAN, even if they're on different switches. In this scenario, only one of your switches needs to be connected to your router—the other is connected daisy-chain fashion to the first switch. The diagram [**Image E**] reveals how this works in practice—we tested this successfully using TP-Link SG108E and TP-Link SG2008 switches.

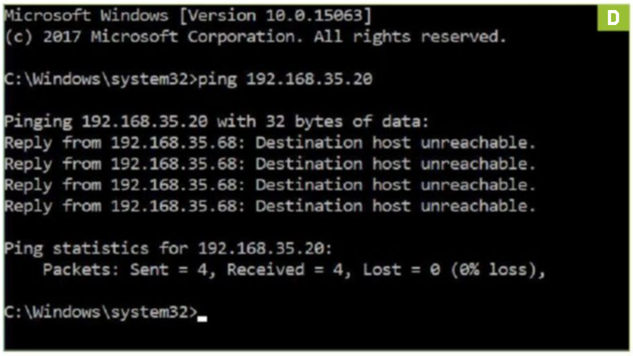
» First, make sure the switches are connected as shown, then open the Easy Smart Configuration Utility on the SG108E, and navigate to the "802.1Q VLAN" section. Follow the advice in step four to set up your two VLANs as shown in the diagram—remember, port 1 is tagged, and all other ports are untagged. Don't forget to set the PVIDs. Click "Save" when you're done.

6 SET UP SECOND SWITCH

Now log on to your second switch—in the case of the SG2008, this is through your web browser using its IP address. Here, navigate to "VLAN." Type "101" into the "VLAN ID" box, and click "Create," then repeat to create VLAN 102.

» Next, check the box next to "101" in the VLAN table. Set port 1 to untagged and port 2 to tagged, both with a PVID of 1, and set ports 3–5 as untagged, with a PVID of 101 [**Image F**]. Click "Apply," then select "102" in the VLAN table, set ports 1 and 2 as previously, and ports 6–8 to untagged, with a PVID of 102. Click "Apply" again.

» You should now find that devices can only see other devices within the same VLAN using the ping test. Internet access should be available to both VLANs. Any devices connected to either switch that aren't placed in either VLAN remain visible to both VLAN groups and the rest of your network. Job done.



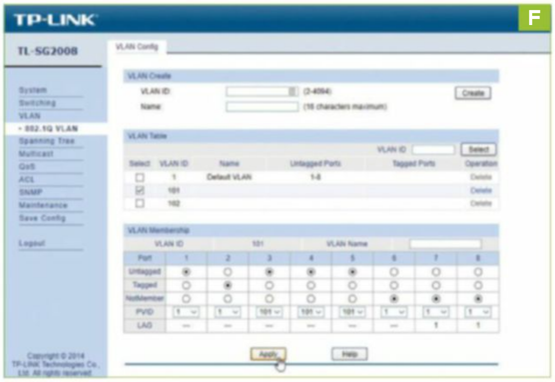
```
Microsoft Windows [Version 10.0.15063]
(c) 2017 Microsoft Corporation. All rights reserved.

C:\Windows\system32>ping 192.168.35.20

Pinging 192.168.35.20 with 32 bytes of data:
Reply from 192.168.35.68: Destination host unreachable.
Reply from 192.168.35.68: Destination host unreachable.
Reply from 192.168.35.68: Destination host unreachable.
Reply from 192.168.35.68: Destination host unreachable.

Ping statistics for 192.168.35.20:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),

C:\Windows\system32>_
```



VLAN ID: (2-4094)
Name: (16 characters maximum)

Select	VLAN ID	Name	Untagged Ports	Tagged Ports	Operation
☐	1	Default VLAN	1-8		Delete
☑	101				Delete
☐	102				Delete

VLAN ID: 101 VLAN Name:

Port	1	2	3	4	5	6	7	8
Untagged	●	○	●	●	●	○	○	○
Tagged	○	●	○	○	○	○	○	○
NotMember	○	○	○	○	○	●	●	●
PVID	1	1	101	101	101	1	1	1
LAG	—	—	—	—	—	—	1	1

SUBNETS AND VLANS

When you want to divide a physical network up, each separate part is known as a subnet. You can identify which subnet a device belongs to by the first three numbers in your IP address—for example, 192.168.0. Networked devices can only see other devices on the same subnet, so a device with an IP address of 192.168.0.2 can see another device on the same physical network with an IP of 192.168.0.3. It cannot, however, see one with the IP address 192.168.1.3, because 192.168.1 is a separate subnet.

VLANs work in a different way—instead of carving up the network into different subnets, they insert a tag or "magic packet" into network traffic sent to and from the VLAN, ensuring it's filtered accordingly.

Make Cut-Out Text in Photoshop

YOU'LL NEED THIS

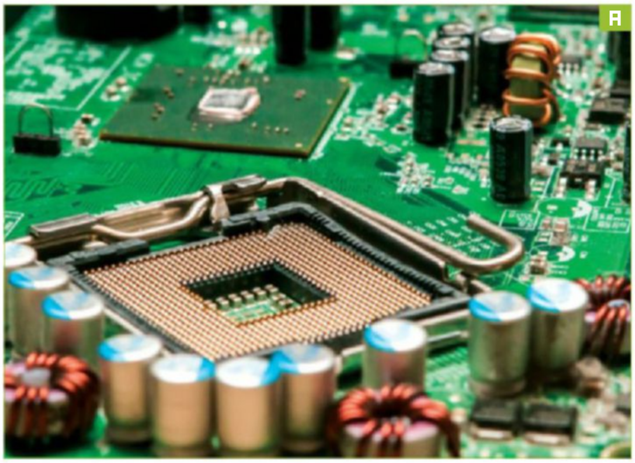
ADOBE PHOTOSHOP
Subscribe to an app or package at www.adobe.com.

BACKGROUND IMAGE
You also need something you want to say.

CUT-OUT TEXT is a staple of the advertising world, and Amazon Prime's *Preacher* series uses it to great effect in its titles. Blending images and text in this way looks stylish, and has uses far beyond violent, stylized comic-book adaptations.

Photoshop has some sophisticated typography tools, the match of those in some page layout software, and full support for vector fonts, so you can do just about anything you like with lines of text—you can even set full paragraphs if you want, but Photoshop isn't really the best application for doing that.

Rather than cutting out parts of your background image and pasting them over your letter shapes, to give the impression that the letters have been turned into holes showing the layer underneath them, you actually do turn the letters into holes. It's called a "clipping mask" in Photoshop parlance, and it's used for all kinds of graphic design elements and special effects tricks. Master this, and there's nothing you can't do in Photoshop. **–IAN EVENDEN**

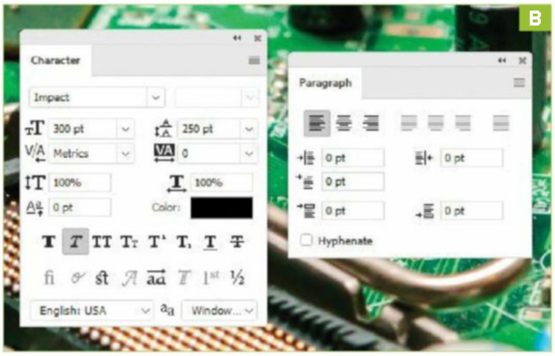


1 CHOOSE A BACKGROUND IMAGE

A little planning goes a long way here. You want an image with an area that will still be interesting when you put the text over it and only part of it is visible, coupled with some strong interest in the areas not covered in text. If your background image is recognizable enough, you can go ahead and completely cover it in text, but make sure the letterforms fall in such a way that the most recognizable parts of the image show through—the eyes and mouth if you're using a face, for example. We've chosen a photo of a motherboard [**Image A**], as if this magazine wasn't already full enough with them, and what a beauty it is: that pin-grid array, that ZIF locking lever, those capacitors.... We get the shivers just thinking about it.

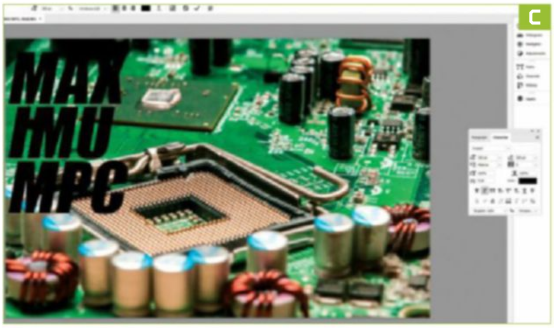
2 FIND A FONT

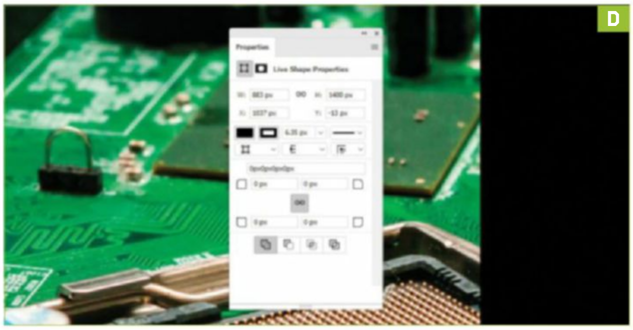
Enough of that. Let's cover up the board's nakedness with some text. Choose your font with care, because a typeface can say a great deal about your project, even before a viewer has begun to read the words. Some are designed for use in large blocks of running copy, while others are meant for shouting headlines, and some are novelty typefaces, meant for decoration as much as conveying information. What we're saying is: Don't cover your image in Comic Sans or Strumpf if you want to be taken seriously. Also, consider the layout of your lettering. Groups of three letters look good, but whole words arranged in a vertical stack can also have a lot of impact. Don't try to cram too much in, because readability from a distance is key with a design like this.



3 TWEAK YOUR TEXT

The "Character" panel, found under the "Window" menu, and its brother the "Paragraph" panel [**Image B**] are the ones you need to control type in your composition. As you've probably deduced from their names, "Character" is for use on individual letters, while "Paragraph" affects whole blocks of text at a time. They do slightly different things, with "Character" geared toward letter sizes and spacing, while "Paragraph" contains options for alignment and indents. Type out your text, use Enter to put it on as many lines as you want, select it with the mouse, and use "Character" to change font size.





The standard Photoshop drop-down menu only goes as high as 72pt, which in these days of high-resolution images looks comically small. We had to go up to 300pt for our image, which isn't particularly large. Adjust the vertical spacing of your lines using the box with two letter As on top of one another—for tight spacing, make it less than your point size—we went for 250pt [**Image C**]. Using the two capital T boxes, you can adjust the height and width of your letters, while V/A is for kerning (how close the letters are to one another). Play around, and get your text looking the way you want.

4 ADD SOMETHING TO CUT THROUGH

Getting on to the clipping mask, first we need to provide it with something to clip through. We're going to use the Rectangle tool to create a simple black rectangle that covers half our image. This appears as a Live Shape, and therefore on its own layer, so there's no need to create a new one first. Move your text so it's on the same side of your image as the black rectangle.

5 RE-ARRANGE YOUR LAYERS

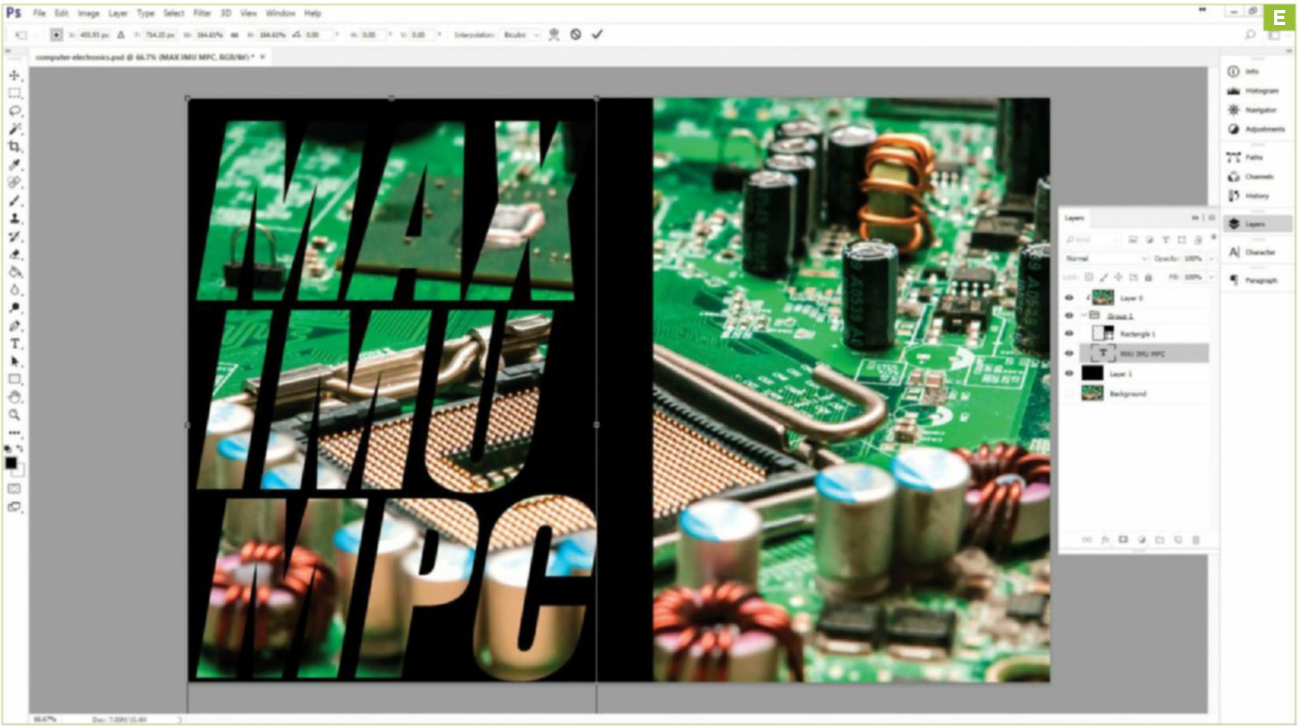
Now we need to do a little layer shuffling. Create a new layer and fill it with black, or a color that fits your image and the mood you're trying to convey, placing it just above "Background" in the stack [**Image D**]. Double click "Background" to turn it into a normal layer, and move it to the top of the stack. Select your text and rectangle layers, and use Ctrl-G to group them, placing them second in the stack.

6 CLIP AWAY

Now for the clipping. Right-click the top layer and select "Create Clipping Mask." Immediately, you should be able to see through to the layers below [**Image E**]. The clever thing about these masks is that your text remains editable, and you can still play with Blend modes to change how the layers relate to each other—though they may not respond precisely as you expect. The rectangle shape can be altered by selecting its layer and using "Edit Free → Transform." Keep in mind the way the layers are stacked, if you're wondering why fading a layer out is affecting a completely different part of the image. Save your work as a PSD file to preserve the layer structure, and export as a PNG when you want to share it, using "File → Export → Export As." Adobe is in the process of retiring "Save For Web," but if you want to use it instead, it's still there on the "Export" menu, marked "Legacy."

WEAR THE MASK

Masks are incredibly useful in Photoshop, but operate slightly differently from selections, and can feel like they come from a backward dimension. When you select, you're choosing pixels you want to operate on. When you mask, you're choosing the pixels that will fall outside the area being affected by what you do next. So, if you use a Quick Mask to paint over the face in a portrait, for example, you'll get a selection at the end of the process that excludes the face, and you need to go to "Select → Inverse" to get the same result as if you'd gone over the face with the Quick Selection tool.



BUILD IT

ZAK STOREY, DEPUTY EDITOR

Coffee Flavored Processing

Our Coffee Lake build hints at the new zero-point

LENGTH OF TIME: **1–2 HOURS**

LEVEL OF DIFFICULTY: **EASY**

THE CONCEPT

AS CONSUMERS, it's our responsibility to give the industry crap if it's failing us. It's the very notion of a capitalist democracy: If you don't like something, change it; if you can't change it, make your voice heard.

People were fed up with four cores being the mainstream norm, so AMD responded with its Ryzen lineup. Eight months on, we're witness to Intel's response: Coffee Lake. With its confusing architectural lineup, an increase in core count finally makes it to the company's mainstream processors.

Although lacking some of the wow factor associated with a new architecture, at the top end Coffee Lake provides six of Intel's highly refined Kaby Lake cores, with slight tweaks to power efficiency and base clocks, at a similar, if not identical, price. What you're left with is a processor capable of ripping up any multithreaded application, while retaining the title of single-thread processing king. That's not to say it's perfect—the top-end part is hot, exceedingly so. The addition of those two extra cores hasn't come for free, and coupled with Intel's continued refusal to provide any form of suitable TIM material between the IHS and the die, you're left with a six-core, 12-thread part that can generate 80 C of heat at stock under load. That's hot—and not the sexy kind.

Coffee Lake's real gem is the Core i5-8400. At just $190, it's six cores and six threads of well-balanced performance, without the crazy temperature issues of the 8700K.

ALMOST BUDGET

THE CORE i5 SERIES has always been centered around gamers. Its heritage goes back a long way, to the days of the Core i5-2500K and Sandy Bridge, as the chip of choice for anyone wanting to enjoy a casual gaming session. As such, it's one of the world's more popular chips, at least in the custom PC ecosystem.

This issue, we decided to recreate that idea of a perfect mid-range gaming system. One capable of driving what we consider the new mid-ground for resolution: 1440p with relative ease at 60fps. But what do you pair with a Core i5 to really give it a kick?

We knew we wanted to run a GTX 1070 in this build—our MSI Gaming X being a solid choice for that position. As far as 1440p goes, the GTX 1070 is the perfect budget GPU, bringing last-gen Titan X performance to mainstream prices.

On top of that, we threw in a healthy 16GB of DDR4, alongside a 480GB Crucial BX300, and a 1TB Seagate Constellation.2 2.5-inch hard drive—the latter being particularly important. Deciding to invest in a quiet 1,200W full-size PSU alongside a 360mm AIO meant we had to ditch the hard drive caddy for 3.5-inch drives below the PSU cover. However, Fractal includes a neat little 2.5-inch mounting tray behind the motherboard. Simply invest in a small form factor high-capacity HDD, and the problems are solved, leaving us with 1.5TB of workable storage for all our applications and media.

INGREDIENTS

PART		STREET PRICE
Case	Fractal Design Meshify C	$80
Motherboard	Asus ROG Maximus X Hero	$260
CPU	Intel Core i5-8400	$190
Memory	16GB (2x 8GB) Corsair Vengeance LPX @ 3000	$163
GPU	MSI GeForce GTX 1070 Gaming X 8G	$445
PSU	1,200W Thermaltake Toughpower Grand	$218
Storage 1	80GB Crucial BX300 2.5-inch SSD	$145
Storage 2	1TB Seagate Constellation.2 2.5-inch HDD	$68
Cooling	Thermaltake Floe Riing RGB 360 TT Premium Edition	$200
OS	Windows 10 Home	$90
Total		$1,859

1

STRIP DOWN

WHEN BUILDING A NEW SYSTEM, we usually recommend that you strip your chassis down as far as you possibly can. Remove all the panels, and place them out of the way, in the box that the case was delivered in. This means that you won't damage the panels as you put your system together, and you'll have more room to work in. With the Meshify chassis, because the I/O is located on the top and front of the case, it's impossible to fully remove that front panel without damaging the cables. Simply put, carefully remove the panel only when you want to install fans or radiators in the front of the chassis.

2

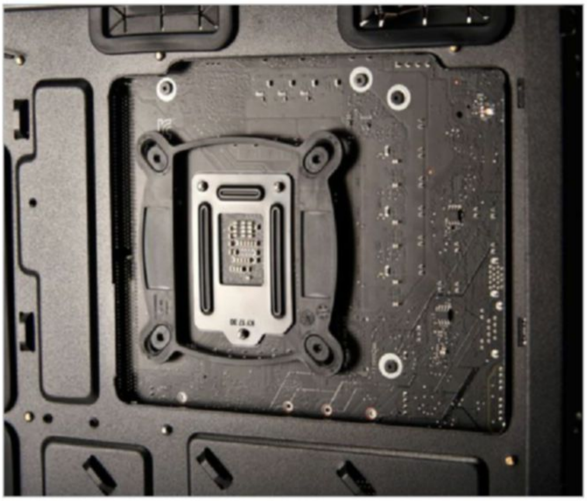
MODULAR PSU INSTALLATION

MODULAR POWER SUPPLIES ARE GREAT for a number of reasons. For starters, they reduce the amount of cable clutter inside your build. They are often higher specced and more efficient than their non-modular cousins as well, and they tend to be easier to install, too. That said, when installing a PSU like this, you should figure out just what cables you're going to need to use, then plug them into the PSU while it's outside the chassis. It'll save you time and frustration in the long run, because there's nothing worse than clipping in those connectors under a cramped PSU cover, as in the Meshify C.

3

CUT-OUT HEAVEN

GENERALLY SPEAKING, when it comes to AIOs, you should almost always attach the backplate to the CPU block before you install the motherboard into the chassis, unless the case comes with a motherboard backplate cut-out like this. Fortunately for the Meshify, it's one of the cases where you can ignore the general rule—thanks to the tremendous size of the motherboard cut-out, you can install your motherboard first, then secure the backplate in place afterward.



4

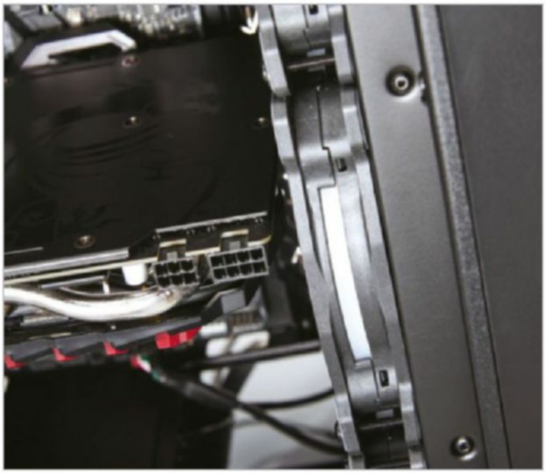
360MM AIO

WHEN IT COMES to all-in one liquid coolers, you're often limited by the sizes on offer. Thanks, in no small part, to the patents that Asetek has taken out on its cooling technology, it can be somewhat challenging to find anything above 280mm in size. Fortunately, Thermaltake is one of the few manufacturers that still go up to and beyond that 280mm limitation. The 360mm Riing Floe is perfect for any toasty Coffee Lake processor—even our Core i5-8400 sits merrily at just 40 C. There are some additional superfluous cables that come with it, which connect to a USB RGB fan hub, but that aside, this is the perfect AIO for our build.

5

TIGHT SPACES

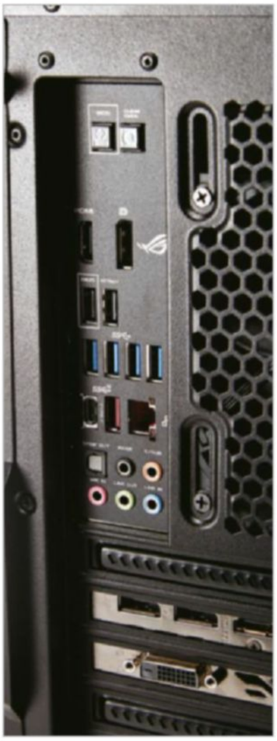
WE'RE QUITE FORTUNATE we didn't pick a larger GPU. Although the Meshify C is technically an ATX midi tower, it's worth remembering that C notation in its name. It stands for "compact." And it certainly is. Install a full-length rad in the front, and GPU length suddenly becomes food for thought. If you do decide on a longer card, yet still want to retain that cooling, you'd have to drop down to a 240mm AIO, and mount it in the roof instead, then install three additional fans in the front, for better air intake.

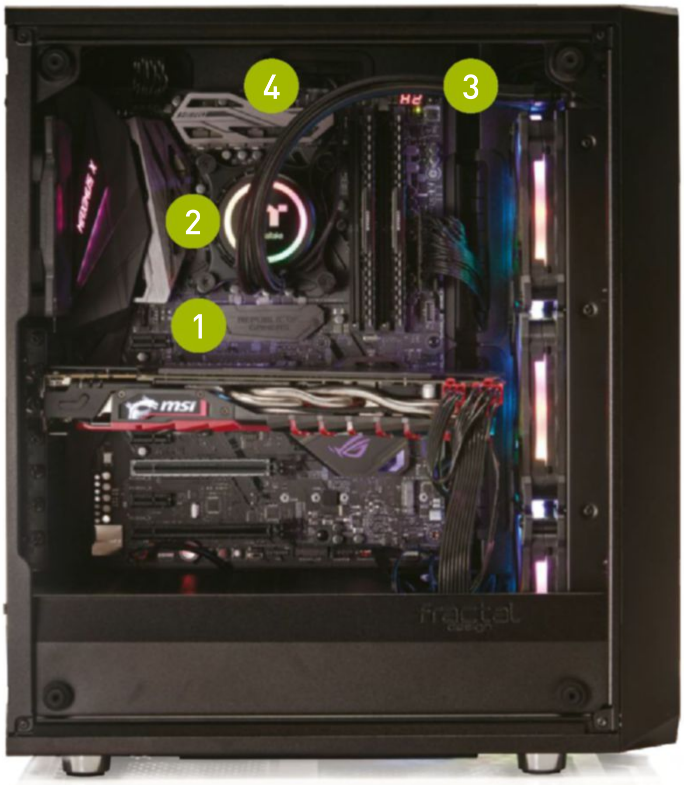


6

I/O LACKING?

ONE OF the better features that Asus has started to include on some of its motherboards is an integrated backplate. No more installing (or completely forgetting to install, in our case) I/O shields—you simply need to line your motherboard up, install it, and job done. However, we've got to admit that, for a $250-plus motherboard, the Maximus X Hero is running a little thin on the ground when it comes to rear I/O. We would have liked to see more than the mere seven USB ports that are included here—today's age of USB peripherals galore could lead to a shortage of suitable connections.





1 Asus has really worked hard on integrating its M.2 heatshields into the design of its mobos. They look great, and help to alleviate thermal throttling during heavy sequential workloads.

2 Unfortunately, Thermaltake's Floe Riing RGB tech isn't compatible with other system sync RGB software setups, such as Asus's Aura Sync or MSI's Mystic Light.

3 BIOS debug codes are exceptionally useful when it comes to diagnosing exactly what's going on if your system isn't booting. Spoiler: It's usually memory.

4 Yeah, we're not really sure why Thermaltake decided to put the tubes in front of the logo either.

FULL OF BEANS

WE'VE THOROUGHLY ENJOYED the processor race of the last year. From Kaby Lake to Ryzen to Coffee Lake, 14nm has produced some absolute gems. And we can safely say that older parts—even our favorite, the Intel Core i5-2500K—might finally be drawing their last gasps, as single-core performance and core count increase so dramatically.

All in all, this build was a pretty smooth ride. We had a few issues with placement fairly early on, but it all worked out in the end. The triple rad in the front caused the most issues. We did intend to use a 2TB 3.5-inch drive in the lower hard drive cage, under the PSU cover, but as we had a large PSU and that rad in the front with the fans, we couldn't fit it all in, so had to use a 2.5-inch instead. Not the end of the world, but we do expect it to affect performance in games and media load times. We were saved by Fractal's mounting tray across the back of the motherboard cut-out, which supports up to three 2.5-inch devices.

More Thermaltake rage came in the form of the cooler's RGB fans. Fortunately, they only have one cable, but they are USB-headed, and plug directly into an included USB hub, which then plugs into a molex power, then into a USB port on the motherboard, forcing you to use Thermaltake's software, and adding excessive lengths of cable to the build—less than ideal for the Meshify's already compact compartmentalization.

Moaning over—how was performance? Pretty damn good. It's amazing how far Intel has come just by adding two more two cores to the majority of its lineup. Seeing those multithreaded scores climb as high as 956 points, for a $190 part, is pretty awesome for Team Blue. That's just a touch off the pace of our zero-point's overclocked Core i7-6700K. But if you compare the Core i5-8400 against its $190 competitor from AMD, the Ryzen 5 1500X, it starts to paint a better picture. Single-core performance is 12 points higher, multi-core 150 points higher, and you don't have to worry about potential memory compatibility issues. The big difference lies in Intel's reluctance to unlock all of its processors, though. Hypothetically, you can still overclock the 1500X, eking out just enough performance to surpass its competitor.

So, is this the core to have? We'll let you decide, but for a mid-range build, it's perfect for demolishing that 1440p target alongside a GTX 1070. We saw average frame rates at 1440p sit comfortably at 67 and 64fps in *Far Cry Primal* and *The Division* respectively, with 38 and 35 in *Total War: Attila* and *Rise of the Tomb Raider*. It's a cool, well-equipped rig, with enough grunt to future-proof you for the next five years, minimum, and that's something we can definitely get behind. ⏻

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi-Thread	987	956 (-3%)
Cinebench R15 Single-Thread	196	166 (-15%)
TechARP's X264 HD 5.0.1 (fps)	21.93	21.43 (-2%)
CrystalDisk QD32 Sequential Read (MB/s)	1,895	525 (-72%)
CrystalDisk QD32 Sequential Write (MB/s)	949	475 (-50%)
Rise of the Tomb Raider (fps)	41	55 (34%)
The Division (fps)	78	91 (17%)
3DMark: Fire Strike (Index)	15,026	15,440 (3%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point PC uses a Core i7-6700K CPU @ 4.6GHz, an AMD R9 Fury X, and 32GB of RAM. All games are tested at 1080p on max settings, with HD texture packages installed.

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REVIEWS

TESTED. REVIEWED. VERDICTIZED.

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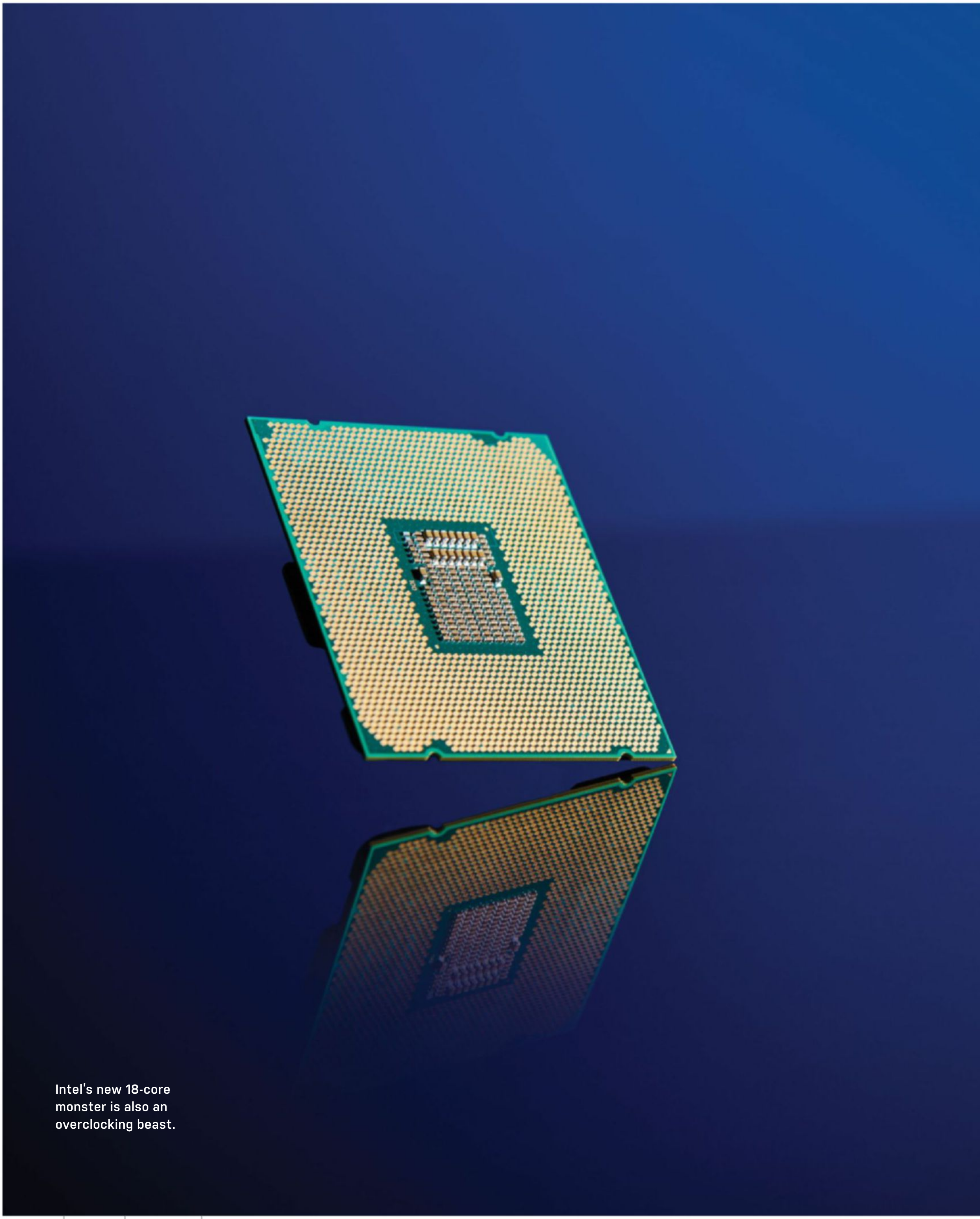


Intel's new 18-core monster is also an overclocking beast.

Intel Core i9-7980XE

Be careful what you ask for. You might just get it…

SO IT IS WITH Intel's new Core i9 megachips. For years, we've been begging Intel to cut the crap and launch some really exciting CPUs that properly push the boundaries of performance. After all, Intel's Xeon server chips have offered huge core counts well beyond its desktop lines for years.

Then Intel suddenly revealed plans for chips with up to 18 cores and, somehow, there was skepticism. It seemed like a cynical ploy to undermine the impact of AMD's Ryzen Threadripper processors. That notion was only enhanced by the fact that Intel announced the new many-core models without revealing detailed specifications. Knee jerks all around, in other words.

But we're far beyond rumored spec sheets now. Today, we have the Core i9-7980X, the $2,000 daddy of them all, in our dirty paws. And what a monster it is. The 18 cores and 36 threads you already knew about. To those you can add a base clock of 2.6GHz, a Turbo speed of 3.4GHz, and a TurboMax of 4.4GHz. If that 2.6GHz figure looks pretty puny, in practice the actual operating speeds of these new many-core chips are quite complex. They involve a sliding scale that starts with that preferred-core 4.4GHz, and gently tails off to 3.4GHz with all 18 cores heavily loaded, albeit with the proviso that the AVX floating point engines aren't maxed out. In that scenario, speeds will be lower, though it's not clear how much.

In between, there's a number of intermediate frequencies that come into play when several cores are loaded, but not all 18. For instance, with between 5 and 12 cores under load, you can expect a frequency of 3.9GHz. Whatever, from all of this there are two take-homes. First, forget about that modest-looking 2.6GHz. Nearly all the time, this is, at worst, a 3.4GHz chip. Second, when the core counts get this high, even the seemingly simple question of how fast a CPU runs becomes complicated.

Elsewhere, the specs look as beefy as you'd expect. The 7980XE, of course, slots into Intel's LGA2066 socket, hooks up to four DDR4 memory DIMMs, and supports quad-channel frequencies up to 2,666MHz. You also get 1.375MB of L3 cache memory per core for a grand total of 24.75MB, plus 44 PCI Express lanes directly into the chip. That latter figure is, perhaps, the only area where the 7980XE looks a little lightweight versus its AMD Threadripper nemeses. Those AMD CPUs pack 64 lanes.

What Threadripper can't do—not even the top 16-core model—is match the 7980XE's stellar all-around performance. Doubters, prepare to suck it up. This CPU flies. It hammers the AMD competition in single-threaded tests. Intel's cores are still the best in the business in stand-alone terms. But the contest in multithreaded workloads isn't such a given, what with AMD's clever modular approach using two CPU dies to Intel's monolithic architecture. But, in the end, Intel owns it all.

The 7980XE sails straight past the Ryzen 7 1950X's 3,012 points in Cinebench to record 3,331 points. Similarly, it's ahead at 41fps to 38fps in x265 video encoding. In Fry Render, the gap is even bigger, with the Intel chip completing the test in 64 seconds to AMD's 85.

As for games, the headline benchmark results don't tell the whole story. Intel's architecture doesn't need any complicated game modes, and it doesn't suffer from stutter in some titles, like AMD. It's comfortably the better option for gamers. As if all that wasn't enough, the 7980XE is an overclocking beast. We got it running at 4.4GHz on all 18 cores, at which speed it clocked a crazy 4,284 points in Cinebench, not to mention over 500W power draw at the wall. In short, this is easily the fastest and finest CPU in history. As well it should be for 2,000 bucks. **–JEREMY LAIRD**

VERDICT
9
KICK ASS!

Intel Core i9-7980XE

+ MORE CORES Epic all-round performance; much better overclocking headroom than expected.

– MORE MONEY Epic price tag; a little short on PCIe connectivity versus AMD.

$2,000, www.intel.com

BENCHMARKS

	Intel Core i9-7980XE	AMD Ryzen Threadripper 1950X
X265 Benchmark (fps)	**41.12**	38.29
Cinebench R15 Single (Index)	**184**	167
Cinebench R15 Multi (Index)	**3,331**	3,012
Fry Render (Seconds)	**64**	84
AIDA64 Memory Latency (ns)	**88**	**88**
Total War: Attila (fps)	**41**	35
Far Cry Primal (fps)	**77**	75
3DMark: Fire Strike (Index)	18,351	**18,899**
Power Draw Idle (Watts)	**66**	91
Power Draw Load (Watts)	**258**	271

Best scores are in bold. Our test bed consists of an Asus X299 Prime-A, an Asus Crosshair VI Hero, 32GB (4x 8GB) of Corsair Dominator Platinum DDR4, an Nvidia GeForce GTX 1080, and a 500GB Samsung 850 Evo. All games were tested at 1440p on the highest graphical profile.

SPECIFICATIONS

Base Clock	2.6GHz
Turbo Clock	4.2GHz/4.4GHz
Cores	18
Threads	36
Lithography	14nm
Cache	24.75MB L3
Memory Support	DDR4 2,666MHz
Memory Channels	Quad
Max PCIe Lanes	44
TDP	165W

Intel Core i7-8700K

Day-old coffee, or freshly brewed espresso?

IT'S BEEN ONE HELL OF A YEAR for processor launches: Kaby Lake, Ryzen, Threadripper, Skylake-X, Kaby Lake-X, and now Coffee Lake as well. That's six different SKUs in less time than it takes to spit, each housing a plethora of fantastic advances for the computing enthusiast. It's hard to deny just how much of an effect AMD's Ryzen has had on the industry. Intel, in particular, has upped its game in response to the multithreaded prowess of the red core. And that response has come in two forms: Skylake-X to combat Threadripper at the high end, and Coffee Lake to take the fight back to the mid-range.

So, then, what's so different? To be honest, not a lot. Coffee Lake's architecture isn't very different from its Kaby Lake predecessor—it's more a refinement of that architecture, which is, in itself, a refinement of Skylake. The big difference lies in core count. Intel has reshuffled both core and thread counts across its range. The Core i7-8700K features 6 cores and 12 threads, the Core i5 has six cores and six threads, the Core i3 comes with four cores and four threads, and (if the rumors are to be believed) the Pentium has just two cores and four threads.

It's still shy of the eight cores found on AMD's Ryzen 7 1800X. However, Intel is banking on its outstanding single-core performance, memory support, established platform, and competitive pricing to level the playing field. And they certainly do.

The Core i7-8700K is impressive. Although architecturally identical to its predecessor, both its synthetic and real-world benchmark performance is exceptional. Scoring 1,553 points in Cinebench R15 puts it just 60 points behind the Ryzen 7 1800X. The big difference, though, lies in that single-core performance, as expected—the 8700K comes in at 205 points, versus Ryzen's 159. This also translates in-game, because it scores higher than any of the processors we've tested in the last year.

And there's the clincher: Intel's core architecture is a well-established platform. Whether it's memory support, in-game performance, or platform reliability, it just all works. There are caveats to this "more cores" approach, however. We've seen power draw increase by over 88W under load, compared to the last-gen Core i7-7700K, even drawing 10W more than Ryzen's 1800X, and temperatures are elevated, too. Under our 280mm AIO, temps easily hit 70 C or more at stock.

It's a well-established fact at this point that Intel still refuses to solder the IHS to the dies of its CPUs, leading to higher temperatures overall. It's disappointing, although the Ryzen parts aren't exactly chilled chips, either. Adjusting the manufacturing process to go back to that Sandy Bridge-style of solder would have alleviated these temperature issues, and allowed for beefier stock clocks on the majority of its parts, without necessarily losing out on stability, potentially enabling team blue to surpass AMD's Ryzen flagship with little risk.

Because of that, the overclocking is equally not as stellar an experience. Although we managed to get our chip up to 5.2GHz (maximum true turbo sticks resolutely at 3.7GHz), both temperature and stability held us back from going any further. Again, we're at that point where the only solution would be to delid the processor to take it higher, something not exactly enticing for the average user.

The Core i7-8700K is an impressive retaliatory blow to AMD's Ryzen. It comes at an attractive price, on an already well-established platform, and unless AMD can really drop the price points on its Ryzen components, it makes far more sense for everyday upgraders to opt for team blue over team red, at least until Ryzen 2 arrives next year. **–ZAK STOREY**

VERDICT **8**

Intel Core i7-8700K

+ DOPPIO ESPRESSO Swift response from Intel; versatile chip; cost-effective.

– INSTANT COFFEE Temperatures high on launch; little change except core count.

$380, www.intel.com

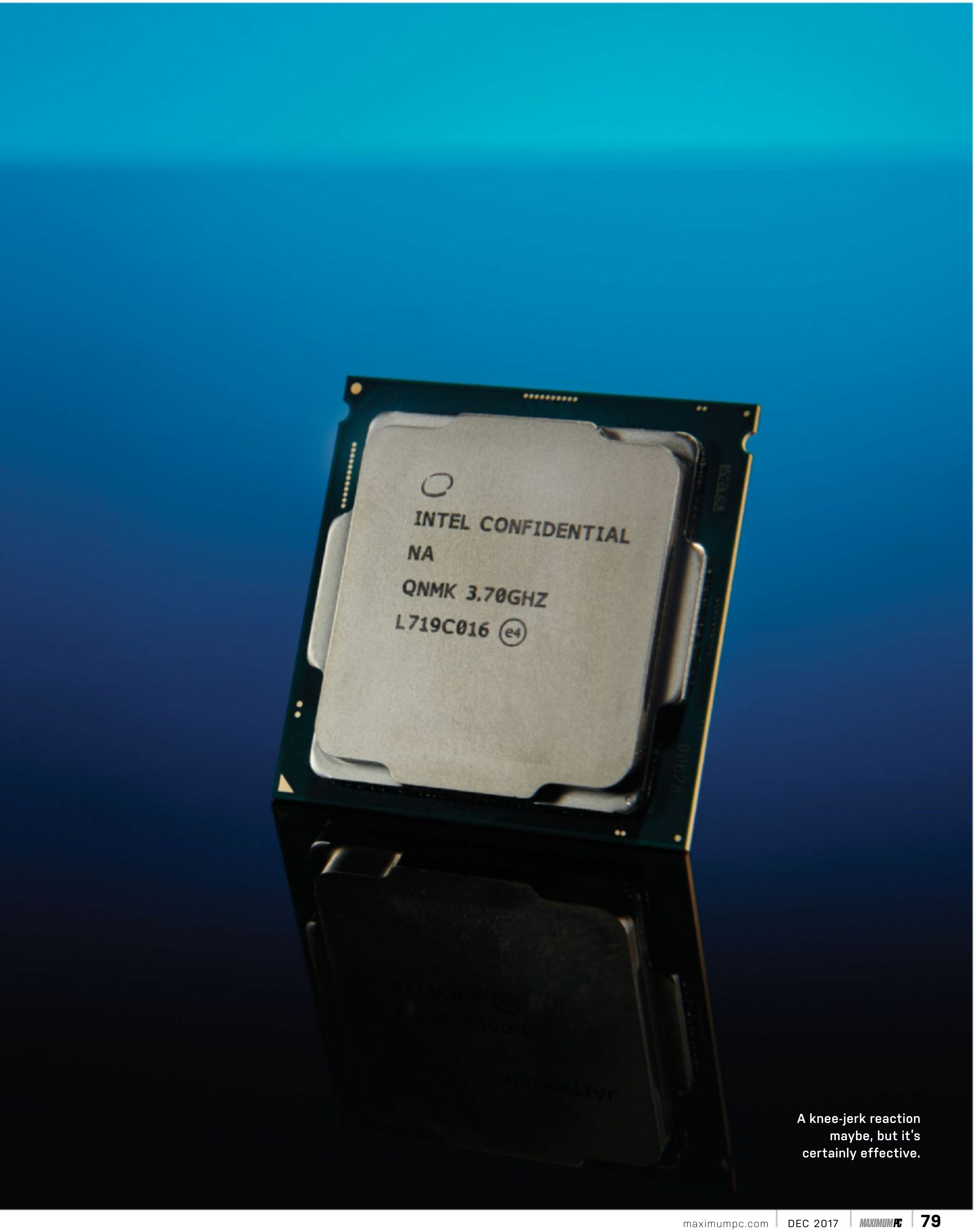
BENCHMARKS

	Intel Core i7-8700K	AMD Ryzen 7 1800X	Intel Core i7-7700K
X265 Benchmark (fps)	**30.65**	27.89	20.68
Cinebench R15 Single (Index)	**205**	159	194
Cinebench R15 Multi (Index)	1,553	**1,612**	970
Fry Render (Seconds)	**133**	161	225
AIDA64 Memory Latency (ns)	48	98	**44**
Total War: Atilla (fps)	**41**	39	**41**
Far Cry Primal (fps)	**77**	75	**77**
3DMark: Fire Strike (Index)	**18,879**	16,433	17,948
Power Draw Idle (Watts)	65	56	**44**
Power Draw Load (Watts)	198	182	**110**

Best scores are in bold. Our test bed consists of an Asus Z370 Maximus X Hero, 16GB (2x 8GB) of Corsair Dominator Platinum DDR4, an Nvidia GeForce GTX 1080, and a Samsung 850 Evo 500GB SSD. All games were tested at 1440p on the highest graphical profile.

SPECIFICATIONS

Base Clock	3.7GHz
Turbo Clock	4.7GHz
Cores	6
Threads	12
Lithography	14nm
Cache	12MB
Memory Support	DDR4-2666
Memory Channels	Dual
Max PCIe Lanes	16
Graphics	Intel UHD Graphics 630
Graphics Clock	350MHz
TDP	95W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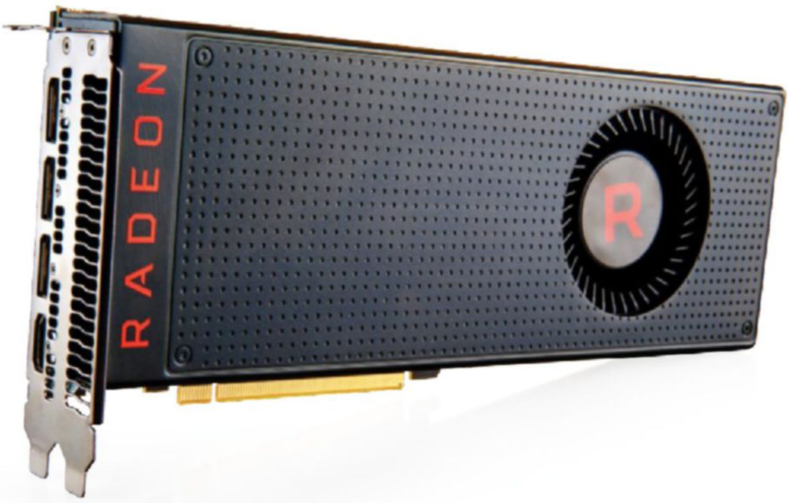
AMD Radeon RX Vega 56

Is this the Vega card worth waiting for?



WE MENTIONED in our upgrade feature (pg. 26) how the Vega series has been a botched launch for AMD. Whether that's the jabbing marketing campaigns, the hushed-up launch, the confusion over initial price rebates, or the horrendous power draw, pricing, and performance of Red's flagship card, it's been less than appealing to jump aboard the AMD hype train. Vega 56, on the other hand, is a different beast. Almost. It's designed to challenge the mid to high-end range of GPUs, sitting snuggly between the GTX 1070 and GTX 1080, at an affordable price.

So, what are the key differences between this and its elderly kingpin, the Vega 64? For a start, the core clocks have been reduced by 90MHz (from a 1,247 core clock down to 1,156), you get 512 fewer streaming cores (limiting it to 3,584), and 32 fewer TMUs (Texture Mapping Units). Everything else is identical, from the ROPs to the 8GB of HBM 2.0 VRAM. The big differentiator is the price. You can currently grab a Vega 56 for a cool $500, compared to the 64's $620. And it's that last part that makes most, if not all the difference.

For the price, Vega 56 is a totally acceptable mid-range 1440p card. In our testing, it easily hit the 60fps sweet spot at the QHD resolution, with an average frame rate of 69 in *Far Cry Primal*, 67 in *The Division*, and *Total War: Attila* and *Rise of the Tomb Raider* scoring 31 and 36 respectively. On top of that, power draw was far more acceptable than its beefier cousin, drawing a maximum of 331W throughout our load testing.

AMD has clearly been working on the latest drivers for these cards as well, because we saw a marked improvement in frame rates since first testing Vega 64. In fact, in some cases, the 56 outperformed the 64's figures on our first testing runs. This helps shunt the 56 slightly higher than the GTX 1070 in most cases as well, with the card registering a 5–10 percent performance increase over its Nvidia rival.

However, there's a problem. Let's get one thing straight: If you're after a card designed to hash out cryptocurrency, Vega is the go-to card right now. Nvidia falls a little flat in this regard, which is good for consumers, and sort of bad for AMD's rep. As the GeForce series is drastically cheaper than its AMD counterparts, if all you're interested in is gaming, Nvidia reigns as king—quite dramatically, in fact. You can pick up a GTX 1070 right now for less than $400. That's a $100 saving for a performance difference of less than 7 percent. For a card that's cooler, quieter, with aftermarket versions available, and drawing less power from the wall, it's hard to argue against it.

Ultimately, the Radeon RX Vega 56 is a solid attempt at capitalizing on the Vega architecture. Its performance and design are decent enough for the price. However, Nvidia still lies unchallenged across the lion's share of the high end, with AMD's only hope lying with Vega 56. And with rumors of a GTX 1070 Ti now seemingly set in stone, it's unlikely that we'll see AMD make its way back into the hearts of gamers and out of the hands of the cryptofiends anytime soon. **–ZAK STOREY**

VERDICT
7

AMD Radeon RX Vega 56

+ **ALPHA LYRAE** Solid 1440p performance; impressive driver updates; AIB cards likely.

− **WEGA** Crypto price hike; hot; loud; power draw still higher than competition.

$500, www.amd.com

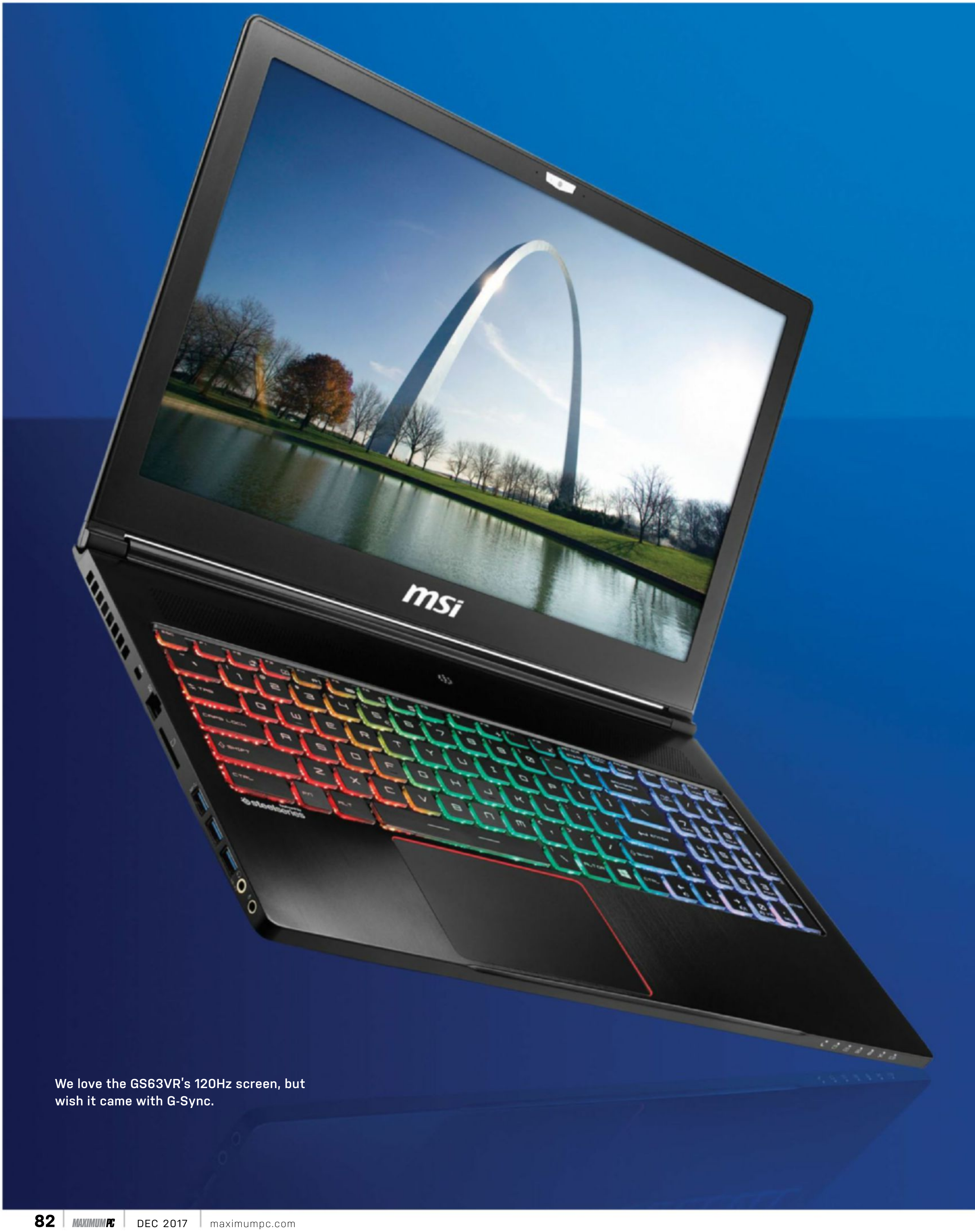
BENCHMARKS

	AMD Radeon RX Vega 56	MSI GeForce GTX 1070 Gaming X
Total War: Attila (fps)	21/31	**23/36**
Far Cry Primal (fps)	**58/69**	55/65
The Division (fps)	42/**67**	**47**/63
Rise of the Tomb Raider (fps)	**22/36**	14/35
3DMark: Fire Strike Extreme (Index)	**8,656**	8,221
3DMark: Time Spy DX12 (Index)	**6,263**	5,753
Power Draw Idle (W)	64	**53**
Power Draw Load (W)	331	**306**

Best scores are in bold. Our test bed consists of an Intel Core i7-7700K, 16GB of Corsair DDR4 @ 2400, an Asus Maximus IX Hero, and a 500GB Samsung 850 Evo SSD. All games are tested at their highest graphical profile, with AA turned up, at 1440p.

SPECIFICATIONS

GPU	Vega
Lithography	14nm FinFET
Transistor Count	12.5 billion
Shader Cores	3,584
Texture Units	224
Core/Boost Clock	1,156MHz/1,471MHz
Memory Capacity & Type	8GB HBM 2.0
Memory Bus	2,048-bit
Display Connectors	HDMI 2.0(b), DisplayPort 1.4



We love the GS63VR's 120Hz screen, but wish it came with G-Sync.

MSI GS63VR Stealth Pro-078

Performance to go

OF ALL THE LAPTOPS we've tested, MSI's GS63VR Stealth Pro is one of our favorites. We've long been searching for a gaming laptop that offers solid 1080p performance in a frame that's not just portable, but is actually light and thin enough to toss in a regular backpack for gaming on the go. The kind of machine that a college student could take to class, or a young professional into a meeting—and not have to worry about loud whirring fans disturbing their colleagues. In short, a MacBook Pro that can play games.

The GS63VR comes pretty close to fulfilling that dream. With an Intel Core i7-7700HQ CPU, 16GB DDR4-2400 RAM, and a 256GB SSD, the GS63VR is nearly identical to (if not a small step up from) the 15-inch Apple prodigy on productivity specs, while its GeForce GTX 1070 absolutely demolishes the Mac's Radeon Pro 555 GPU—all while costing $300 less.

Of course, Apple products have never been known for their frugality. It's the intangibles—design, build quality, and ease of use—that make its products appealing to pretty much everyone who doesn't want to play games. But with the MSI GS63VR, we might have finally found a competitor.

The black aluminum chassis and screen hinges feel solid to the touch, with an elegant, understated design—by gaming laptop standards, at least. The SteelSeries keyboard offers full RGB backlighting, but more importantly, feels great to type on. Similarly, the touchpad is one of the best we've used on a Windows machine. And while MacBooks still reign supreme in the battery life category, we were able to get a modest three hours and eight minutes out of the GS63VR—enough time for back-to-back meetings or a very lengthy movie.

The GS63VR does all this in a frame that weighs in at just shy of four pounds, and measures only 0.69 inches thick—nearly identical to the 15-inch MacBook Pro. But unlike the MBP, it can also play games.

In our gaming tests, the GS63VR pulled in an average of 71fps across *Rise of the Tomb Raider's* three-part benchmark, scoring 95fps in the Mountain Pass, 61 in Syria, and 56 in the Geothermal Valley. *Total War: Warhammer II's* Battle benchmark returned 55fps, while the demanding *Tom Clancy's Ghost Recon: Wildlands* came back at 43fps—all at 1080p using the highest available graphics preset. Performance-wise, this puts the GS63VR and its Max-Q-tuned GTX 1070 on par with a "regular" GTX 1060, as in Asus's ROG Strix GL502VM or Acer's Predator Helios 300.

This is the one area where the GS63VR disappoints us. We knew there would be a performance trade-off that came along with the Max-Q design—after all, light and thin is essentially the antithesis to high-performance. The Max-Q GTX 1080 that we tested in Asus's ROG Zephyrus didn't perfectly match a desktop-class GTX 1080, but it still outperformed the next card down: a desktop-class GTX 1070. By that logic, we knew a Max-Q GTX 1070 probably wouldn't keep pace with a desktop 1070, but we were hoping it would still be a moderate step up from the GTX 1060.

It seems that isn't the case—so, why should you pay over $500 more for a Max-Q GTX 1070 than a regular GTX 1060-powered laptop? We already talked about size and weight. The other key factor is noise. Every GTX 1060-powered laptop we've tested sounds like a jet taking off as soon as the fans spin up. Not here—the GS63VR Stealth Pro lives up to its name. You just won't hear this jet coming. **–BO MOORE**

VERDICT **8**

MSI GS63VR Stealth Pro-078

➕ **STEALTH BOMBER** Light and thin; full-color RGB keyboard; 120Hz screen; quiet.

➖ **BOMBED OUT** Lack of G-Sync; low performance compared to desktop GTX 1070; hot bottom.

$2,099, www.msi.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Single (Index)	155	155 (0%)
Cinebench R15 Multi (Index)	743	744 (0%)
CrystalDiskMark QD32 Sequential Read (MB/s)	563	554 (-2%)
CrystalDiskMark QD32 Sequential Write (MB/s)	133	516 (287%)
PCMark 10 Express (Index)	3,852	4,084 (6%)
3DMark: Fire Strike (Index)	13,202	11,338 (-14%)
Rise of the Tomb Raider (fps)	99	71 (-28%)
Total War: Warhammer 11 (fps)	62	55 (-11%)
Tom Clancy's Ghost Recon: Wildlands (Avg fps)	48	43 (-10%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our laptop zero-point is the Asus GL502VM-DS74, with an Intel Core i7-7700 HQ, an 8GB GTX 1070, and 16GB of DDR4-2400. All game tests are performed at 1080p at the highest graphical profile.

SPECIFICATIONS

Processor	Intel Core i7-7700HQ @ 2.8GHz
Graphics	GeForce GTX 1070 Max-Q
RAM	16GB DDR4-2400
Screen	15.6-inch 1080p 120Hz wide view angle
Primary Storage	256GB M.2 SATA SSD
Secondary Storage	1TB 5,400rpm HDD
Keyboard	SteelSeries RGB
Cooling Solution	Copper CPU heatsink
Battery	3-cell 57Whr
PSU	180W
Weight	3.96lb

Lenovo ThinkPad 720S

Thin, smart, and just powerful enough

LAPTOP ENGINEERING is often a difficult thing to fathom. In this case, we've bent our brains trying to work out exactly how Lenovo's engineers have distorted space and time in order to crush everything they have into this tiny machine. If we drop it on the wrong corner, will we rip open a portal to another dimension? Existential worries aside, the list is mighty impressive. There's a cool, hyper-fast Kaby Lake i5 in the CPU slot, a proper SSD looking after storage, a wholly reasonable 8GB of DDR4 RAM flinging the quick bits about, and discrete graphics, too, in the form of a GeForce 940X mobile chipset. All this in a 0.8-inch thick shell. Plus, presumably, those dangerous boffins have inserted a miraculously miniaturized portable wind tunnel in there—this thing makes a mighty whoosh through its large base-mounted ventilation port when it's under load.

Just as impressive a feat is the gorgeous full HD IPS screen, a slim-bezel number that trims the side and top edges to a minimum, giving more screen real estate in a smaller 13.3-inch shell. It's no Dell InfinityEdge, of course (that's a whole other level of scientific engineering), but Lenovo has at least had the good sense to put the webcam at the top of the panel, rather than Dell's odd off-center screen-base position. Nobody really wants to spend a Skype conversation staring at your neck, after all.

We'd say the crushed keyboard—which has standard-sized backlit keys, with regular spacing, but squashes the arrow keys and all other peripheral buttons into an oddly compacted layout—is a compromise of the unit's size, but Lenovo has replicated that on larger laptops. It must be a Lenovo "thing," just like the ridiculous decision to put the power key—a keyboard key, like any other—right next to Delete and Backspace. Yes, it's almost impossible to accidentally power off your machine, but come on—that's not great design.

POWER GAMES

While Lenovo has definitely filled the aluminum shell of the 720s—and it's a dense little thing, at 3.4lb—it hasn't reserved a lot of that space for the battery. Go calm and you can, as we did, tease out just over five hours from its cells (the company claims 14, which is nonsense), but a decent load, and making the most of discrete graphics rather than the switchable Intel 620 chipset, drops this down to a shade above three hours. These aren't gaming laptop numbers, but it doesn't have gaming laptop power to offer either. That GeForce 940X is a nice extra to have, but it was outclassed upon release, let alone now, over a year later. The 720s is adequate for older games at low to medium settings, but you're completely out of luck with today's AAA titles.

But, then, this really isn't supposed to be a gaming machine. It's about working, and working in relative luxury—the 720s absolutely looks and feels like a premium machine, one that defies its upper-mid-range price point. We could (and, indeed, did) stare at that panel for days on end. We wouldn't be ashamed to whip this out in public, and it's compact enough for airline tables or your lap in the back of a cab. The rhythm section of the machine is a great match; while a little extra SSD space would have been appreciated, 256GB is enough to get by on, and despite slightly slow read times, it's quick enough. Combined with the dual-core i5-7200U and a perfectly adequate RAM supply, this machine doesn't let up on desktop performance.

So, forgive it some sketchy benchmark figures, because raw power isn't everything. Put its little compromises and that cacophonous fan to the back of your mind. The 720s is a remarkable white-coat combination that works for business or everyday pleasure, with enough squeezed inside that you can push it just a little further if you really need to. **–ALEX COX**

VERDICT
7

Lenovo ThinkPad 720S

➕ **LENOVO!** Beautiful, solid chassis; great low-bezel screen; strong desktop performance.

➖ **LEN.. OH NO!** Middling-to-low power; silly keyboard; noisy fan.

$949, www.lenovo.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 (Index)	682	132 (-81%)
TechARP's x264 (fps)	15.17	6.18 (-59%)
CrystalDiskMark 4K Read (MB/s)	44	28 (-36%)
CrystalDiskMark 4K Write (MB/s)	162	150 (-7%)
Far Cry Primal (fps)	37	5 (-86%)
The Division (fps)	33	4 (-88%)
Rise of the Tomb Raider (fps)	42	5 (-88%)
3DMark Fire Strike (Index)	6,583	1,878 (-71%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our laptop zero-point is the Asus G752VT-DH72, with an Intel Core i7-6700HQ, GTX 970M, and 16GB of DDR4.
Rise of the Tomb Raider tested at very high settings with SMAA at 1080p.

SPECIFICATIONS

Processor	Intel Core i5-7200U
Graphics	Nvidia GeForce GTX 940X
RAM	8GB DDR4
Resolution	1920x1080
Display	14-inch IPS
Storage	256GB PCIe SSD
Connectivity	2x USB 3.0, 1x HDMI, 1x USB Type-C, SD card reader
Dimensions	5.35 x 10.47 x 0.78 inches

A small, sexy, and immensely useful laptop.

Crucial BX300 480GB

It's not sexy, but it is great value

crucial
2.5-inch SOLID STATE DRIVE

KEEP THOSE EXPECTATIONS in check. That's not the most enthralling way to approach a new SSD, but it's very much the attitude to have when considering a standard SATA drive, such as the Crucial BX300.

For starters, it's a SATA drive in an age when SSDs hooked up via the far faster PCI Express interface are becoming ever more mainstream. Not only is SATA limited to a real-world maximum throughput of about 550MB/s, but its control protocols were never intended to jive with solid-state memory. That means random access performance is compromised, compared with the full potential of the latest SSD controllers and flash memory.

What's more, the BX300 isn't merely a SATA drive. It's an aggressively priced SATA drive, sold as a value offering, rather than a premium performance proposition. This 480GB model, for instance, costs $145. A top-notch SATA drive in this 500GB-plus-or-minus-a-few-GB category, such as Samsung's 850 Pro, will hit you to the tune of $230. Even Samsung's value drive, the 850 Evo, is more expensive at $170.

So, it's a cheap drive, and with that come those aforementioned reasonable expectations. Do not expect the BX300 to tear it up in the benchmarks. But before we nose around those particular numbers, let's peruse the BX300's speeds and feeds.

Intriguingly, Crucial has wound back the clock technologically, and returned to MLC, or two-level, flash memory cells, each capable of storing two bits of data. Its previous budget drive, the BX200, ran with TLC, or triple-level cells. Indeed, Crucial's premium offering, the MX300, retains TLC.

That said, this isn't old-school planar memory. It's 32-layer 3D NAND memory. In short, due to the slightly unusual 384Gb capacity of Crucial's first TLC 3D NAND memory chips, using them in small, budget-oriented SSDs doesn't add up. Crucial does have more suitable 256Gb and 128Gb chips on the way. In the meantime, a fallback to MLC has proved expedient.

Other highlights include Silicon Motion's latest SM2258 controller chipset, 512MB of cache memory, and a write endurance of 160TB. Peak speeds for the 480GB model are quoted at 550MB/s for reads and 510MB/s for writes. 4K random reads and writes are 95k and 90k IOPS respectively.

As for our tests, the BX300 cranks out some surprisingly good numbers. Sequential throughputs for both reads and writes are well over 500MB/s in ATTO Disk Benchmark. In CrystalDiskMark's slightly tougher test of sequential performance, the numbers are still strong, with 536MB/s for reads and 486MB/s for writes.

Even more impressive for a budget drive are the results in CrystalDiskMark's 4K random access test. The BX300 spits out 33MB/s reads and 130MB/s writes. Those numbers compare favorably with a premium drive, such as Samsung's 850 Pro. In fact, all of the BX300's performance numbers look good next to more expensive SATA SSDs.

Of course, the subjective difference in terms of the computing experience delivered by various modern SATA SSDs has narrowed. You would be hard pressed to tell the difference in terms of how responsive each one makes a PC feel. Arguably of more significance is longevity, and that's where the BX300 betrays its budget intentions.

Crucial provides a three-year warranty, which matches other budget drives. However, Samsung's 850 Pro comes with 10-year cover. In the end, then, you pays your money and you takes your choice. If you need an SSD with maximum staying power, the BX300 isn't for you, and you'll simply need to pay more.

For most, however, three years is a decent lifespan for a cheap SSD. In all likelihood, this drive will keep on trucking for many years beyond. Combine that with very respectable performance for a budget SSD, and you have a pretty awesome value proposition. Just so long as you keep those expectations reasonable. **–JEREMY LAIRD**

VERDICT 8

Crucial BX300 480GB

+ **GREAT EXPECTATIONS** Aggressively priced; solid all-around performance.

− **HARD TIMES** Warranty period is nothing special; doesn't do anything spectacular.

$145, www.crucial.com

BENCHMARKS

	Crucial BX300 480GB	Samsung 850 Pro 2TB
30GB Internal Copy (Seconds)	**126**	263
Atto Sequential Read (MB/s)	**564**	404
Atto Sequential Write (MB/s)	**526**	427
CrystalDiskMark Sequential Read (MB/s)	**536**	524
CrystalDiskMark Sequential Write (MB/s)	486	**497**
CrystalDiskMark 4K Read (MB/s)	33	**34**
CrystalDiskMark 4K Write (MB/s)	**130**	97

Best scores are in bold. Our test bench consists of an Intel Core i7-7700K, an Asus Maximus IX Hero, an Nvidia GeForce GTX 1080, 16GB of Corsair Dominator Platinum DDR4, and a Samsung 960 Pro OS SSD.

SPECIFICATIONS

Capacity	480GB
Interface	SATA
Control Protocol	AHCI
Controller	Silicon Motion SM2258
NAND Type	MLC 32-layer 3D NAND
Sequential Read	550MB/s
Sequential Write	510MB/s
Read/Write IOPS	95/90k
Warranty	Three years

SteelSeries Sensei 310

The perfect pointing device for any paw

HANDS, EH? Weird things. Even if you're not under the influence of mind-bending drugs, looking at your hands for any length of time will confirm just how strange those wiggly flesh-tentacles truly are. Every tried to draw a hand? It's impossible—for good reason. And everyone's fingers are different, so it falls to mouse manufacturers to create pointing devices shaped in such a way that they will suit as many demented digit designs as possible. Most opt for thumb-friendly mouse molds that slot into the right hand. Some, however, are aware that the world is not made entirely of righties, and while we're unlikely to see many manufacturers catering solely to the worldwide left-handed 10 percent, there is such a thing as a mouse for every hand.

And so we have the Sensei 310, far from the first both-ways pointer ever released, but directly marketed as an ambidextrous esports mouse. As you'd expect, it's completely symmetrical, though this doesn't really affect its feel appeal in either hand. The two main buttons, each equipped with Omron mechanical switches, are split from the case itself, rather than being part of the overall lid structure, with a slight ridge to provide a tactile buffer between them and the notched, rubberized scroll wheel. Each edge carries a pair of thumb buttons above a grippy silicon pad, and there's a DPI switcher behind the wheel—it's all fairly standard design, although SteelSeries has managed to make something that feels as at home in regular grip as it does in claw.

The ambidextrousness is a selling point, sure, but its real purpose here is to bring a bundle of super-high-end mouse tech to as many hands as possible. The core of this package is SteelSeries's TrueMove 3 sensor, which promises true one-to-one tracking. This means there's no smoothing, snapping, or acceleration added to your movements to compensate for lag, and what you move is what you get. The counts-per-inch level you're using is precisely what the mouse sends to your PC, and you can set this anywhere from 100 to 12,000 cpi in 100 cpi increments, with a nominal 1ms polling rate.

ARMED SERVICES

Whatever settings you choose are stored in the mouse itself, which also sports its own 32-bit ARM processor, presumably to keep tabs on that ultra-accurate sensor. The storage extends to the lighting, picking out the wheel and palm logo with SteelSeries's excellent synchronized RGB system. SteelSeries Engine drivers are required for initial configuration, but not once you're all set up, so you can cart the Sensei wherever the gaming urge takes you.

In practice, and certainly in terms of desktop use, you may not notice the sensor's skills. Honestly, we couldn't tell the difference even through extensive use; while gaming mice have been great for a long time, a complete lack of acceleration does not, sadly, make this feel like a brand new horizon of pointing, though it does remove at least one source of blame if you lose an online firefight. The sensor itself is also part of a rather simple package, at least in comparison to many of its market rivals. There's little lighting and not much to speak of in terms of buttons, as quality as the switches clearly are. But perhaps that's the point.

This is a raw, unfussy, highly functional mouse. It's not outrageously expensive by any means. It has a sensor that's versatile enough to suit you, whatever your preferences, a shape that will work for your peculiar hands, buttons that feel great, and lighting that you can configure to your liking. The Sensei 310 really has been built for every set of fingers out there. And, hey, if you're picky and like a more molded feel, SteelSeries's Rival 310 is the same package mashed into a curvy right-handed configuration instead. **–ALEX COX**

VERDICT
9

SteelSeries Sensei 310

+ **POINTER** Universal design; super sensor; high-end switches; affordable.

− **DISAPPOINTER** Sensor potentially makes little difference.

$60, http://steelseries.com

SPECIFICATIONS

Sensor	Optical
Sensitivity	Up to 12,000 cpi
Sensor Model	TrueMove 3
Polling Rate	1ms
Programmable Buttons	4
LEDs	2x RGB
Cable Length	6.5ft
Weight	3.2oz

Logitech G613 Wireless Mechanical Keyboard

At last: sexy switches without the cable

WIRELESS KEYBOARDS and mechanical switches don't go together. Or, at least, they haven't before. There are plenty of sensible reasons for the divide between the two technologies, primary of which is the usual proximity between keyboard and PC. Why tack on the extra cost of a wireless interface when the average mech-user is more interested in a flashy, ostentatious, loud experience, one they'll be having at their desk? Why add input lag when the key market for mechanical keyboards is gamers, a group that demands instantaneous response from its peripherals?

Logitech has not put out this high-profile wireless release without a few answers to those questions, the first of which is to strip back the experience as far as possible. For many potential users, we expect the lack of modern conveniences will be a blissful relief from the gimmick-heavy keyboard market of 2017. There's no battery-sucking RGB, or any lighting at all beyond the occasional connection LED and indicators for Caps Lock and the level of its AA batteries. There's no pass-through of any kind, presumably because firing audio through it would likely ruin the wireless response time. There's no harsh angles, unusually-molded keys, or chrome-plastic effigies to some alien god.

What is there is as functional as it is aesthetically mute. A black and gray color scheme with the merest hint of blue, a set of comfortably shaped and clearly labeled (though not double-shot) keys, and Romer-G keyswitches, a co-development between Logitech and Omron, with a high actuation bump, and a satisfying soft feel. Like other Romer-G devices, there's a harmonic ring to the many springs inside the G613 that sings out if you hammer it hard, but otherwise we're more than happy with the experience of typing on them. They're not as tooth-looseningly loud as many switches you'll find, but that's probably for the best.

REST ROOM

Outside the main components, there's an integrated wrist rest, non-detachable, which deepens the G613's footprint, and means it's a joy to use on an outstretched lap. There's a string of six macro keys on the left edge, of which only two are realistically reachable with the pinkie of a game-positioned hand, which limits their immediate usefulness somewhat. There's a set of clicky media microswitches, and a row of connection options—a Windows key-blocking game mode toggle, and buttons to select between Bluetooth operation and Logitech's LightSpeed interface.

About that, then. LightSpeed is some kind of proprietary wireless wizardry straight out of Logitech's labs, and the thing that's probably most remarkable about this keyboard. It drags down input lag to a claimed 1ms. We believe it, too: There's not a shred of sluggishness about the G613, no dropped inputs, a great range. It drops to standby after a couple of minutes, yet wakes instantly on any keypress. On LightSpeed, it's very easy to forget that you're using a wireless keyboard at all.

This does bring us back to our original point, though. While its gray button-down staidness does have a certain retro-classic appeal, and Logitech has clearly taken a little inspiration from the enthusiast market in terms of the old-school key labels, we can't help but feel that the wireless functionality means you lose a lot that a cable might otherwise make trivial. The addition of Bluetooth is a nice touch, particularly as it means you can hook the G613 to a second device and quickly switch to it, but it's not enough to make this essential.

Judged by its merits alone, Logitech's G613 is an excellent keyboard, and LightSpeed is a tremendous wireless technology, but we wouldn't consider paying a full $150 for it if it were a wired model. If you absolutely must have mechanical action, and can only sit 10 feet away from your PC, at last you have a solution—but compromise on just one of those factors, and there are cheaper and more feature-rich keyboards out there that'll serve you just as well. **–ALEX COX**

VERDICT 7

Logitech G613 Wireless Mechanical Keyboard

⊞ **WIREMORE** Pleasant switches; lag-free communication; subtle design.

⊟ **WIRELESS** Nothing extra; high price; awkward macro keys.

$150, www.logitech.com

SPECIFICATIONS

Switch Type	Logitech Romer-G
Form Factor	Full size
Media Keys	Yes
Macro Keys	6
LEDs	No
N-Key Rollover	10 keys
Pass-Through	None
Dimensions	18.8 x 8.5 x 1.3 inches
Warranty	Two-year limited hardware

Razer Tiamat 2.2 V2 Gaming Headset

Are four drivers better than two? Razer runs the numbers

"WELCOME TO THE CULT OF RAZER," says an embossed line of text inside the Tiamat's immaculately presented box, bringing to mind a certain other tech company with a knack for presentation. As with its stablemates in the current Razer lineup, every effort is made to make this headset feel luxurious, starting with the spot UV printed packaging, and going right through to the generous memory foam earpads. On those grounds, it can't be faulted.

An aluminum headband over a memory foam contact pad gives the cans a comfortable fit, without the need for squeaky retractable parts. Indeed, there's very little noise from this model when you adjust it in any direction—moving the mic to purpose, rotating the earcups, and shifting the fit while on your head are all silent operations. A reasonably light 14.6oz overall weight and those aforementioned foam pads make it comfortable to wear for long periods, although synthetic leather and closed cups being what they are, it does get hot around the ears after a while.

BACK-SEAT DRIVERS

The headline act on this revamped Tiamat 2.2's spec sheet, however, is the introduction of two 50mm drivers inside each earcup. At the base of the right cup is a toggle switch, which gives you the power to activate all four drivers, or go with the more standard two. If your internal gimmick alarm's going off at the very mention of this, we feel that. But to Razer's credit, the effect of having all four drivers activated is a well-balanced and warm overall tone. Bass-heavy, yes, but not to the extent that it muddies the mid-range frequencies, and streets ahead of the "no such thing as too much bass" school of gaming headsets, circa 2012. The impedance of each second driver is half that of the primary driver, so it simply offers more punch when listening to music, or a more cinematic sound to games, if that's your thing. We always prefer as close to a totally flat frequency response as possible in a headset—yes, that is like saying we prefer black filter coffee to espressos because you can really taste the beans. Pretentious or not, flat's our thing, yet we did find ourselves reaching for the toggle switch to get a bass fix several times during *Divinity: Original Sin 2* sessions and *PUBG* matches. So, while it might seem a little gimmicky, it's actually a great call on Razer's part to put this choice in your hands.

Let's go into the overall sound with just two drivers activated before we raise the Tiamat 2.2 V2 on our shoulders and start singing it songs, though. While it is a flatter and clearer sound than in four-driver mode, it lacks a bit of mid and high clarity ("sparkle," if we're being filter coffee-drinking posers) that you might hear in Sennheiser's higher end models, although at $130, it's not really going up against the GAME ZERO et al. Instead, it's in the trenches with Kingston's HyperX Cloud Revolver and SteelSeries's Arctis, both of which host impressive audio quality. The mic, set on a malleable hinge arm, is good quality, too, picking up voices without the mechanical keyboard taps beneath them.

There's a big "but," sadly, and unlike Sir Mix-A-Lot, we don't like those. The 4ft cable might just about be considered "braided," but it's noticeably thin and fragile-looking. The same's true of its additional 2ft splitter cable, and right out of the box we had connection problems with the audio jack. In fact, it took significant cable-wiggling to even produce a sound, and in the end we had to resort to taking the extension cable out of the equation. It's a shame to see this otherwise competitive headset hobbled by a flimsy cable, because the addition of four drivers—and, importantly, user control over them—is really enticing. –PHIL IWANIUK

VERDICT
7

Razer Tiamat 2.2 V2

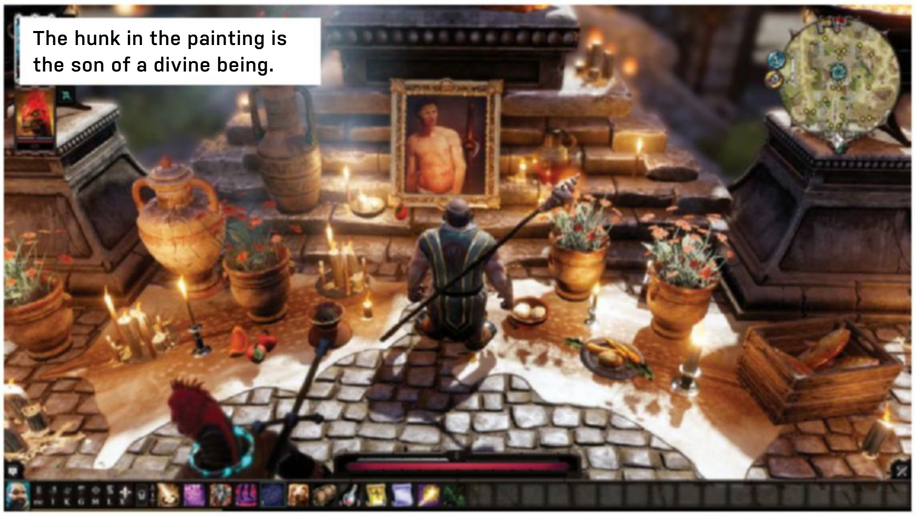
⊞ **RAZER SHARP** Choose two or four drivers; super-comfortable; powerful bass.

⊟ **RAZER BURN** Flimsy cable.

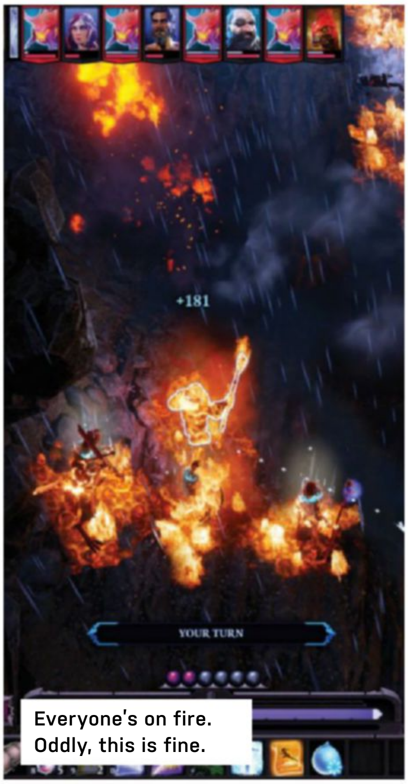
$130, www.razerzone.com

SPECIFICATIONS

Driver Type	4x 50mm
Impedance	32 ohms front, 16 ohms back
Frequency Response	20Hz–20kHz
Design Style	Closed cup
Microphone Type	Unidirectional
Connectivity	3.5mm audio jack
Weight	14.6oz
Cord Length	4ft + 2ft extension



The hunk in the painting is the son of a divine being.



Everyone's on fire. Oddly, this is fine.

Magic sends up a cloud of lighting and particle effects.

Getting into the mind of a lizard prince is hard.

Divinity: Original Sin 2

Every sin here has been done before, we guarantee

THE ISOMETRIC RPG has been a mainstay of PC gaming since the '90s, and feels most at home here, thanks to the high-res screens and mouse input that, until recently, consoles couldn't match.

Original Sin 2 is a sequel to the prequel to the *Divine Divinity* series, thus tracing its lineage back to 2002 and some awful cover art. Today, thanks to Kickstarter's largesse, we have a huge game, oozing the kind of polish we could only imagine in the early '00s, yet some things feel very familiar.

Take the immediate beginning. You wake up on a table, and a huge bell marked "Planescape: Torment" begins to ring. As it turns out, you're not immortal, merely quite easily resurrected, but the rest is up to you. Or not, as Larian Studios has included several ready-baked characters for you to pick from in the character creator. You can still roll your own, but choosing one of the ready-made avatars means you're treated to a full origin story and additional options in dialogue. Of which there's rather a lot.

The backstories are rich, and the dialogue options often helpful and frequently amusing. The pre-cooked also bring a sense of playing a role in the world, rather than just being yourself, as many RPG characters end up. If we can overcome our natural instincts and offer a kind word to a pauper, or maybe flirt with a kitchen maid, because that's what your lusty sea-dog of a character would do, rather than hiding behind our natural shyness, we're in a realm of role-playing streets away from considering "what would I do?"

Every line is voiced, including those of the narrator, so there's a lot to sit back and listen to. It's perhaps not a game for quick-fix playing, because it's all too easy to sink hours into it, but it rewards this time investment with interesting characters and the kind of depth we rarely see. Everyone (including animals with the right ability) can be spoken to, even if they simply tell you to go away, traded with, or murdered. Killing a quest-specific character may close off that avenue to progress, but there are so many ways to do anything, you're hardly ever faced with having to reload in order to un-break your campaign.

The plot, involving powerful magic (which you can't use at the beginning, thanks to a damping collar that needs to be removed), revenge, and the ascendancy to godhood, starts slowly, with a cleverly masked tutorial section laying out the turn-based combat and elemental magic system. The fighting, which happens a lot unless you're very charismatic, is one of the game's weaker aspects, making it all too easy to get bunched up under an area-of-effect spell. The limited action points per turn are to blame for this, despite being a perfectly good system for turn-based brawling, as you're more likely to want to use them for attacks rather than movement. Again, you must play a role—that of someone who wants to get out of this alive, rather than someone who wants to see particle effects.

Built on top of the Enhanced Edition of the previous game, and benefiting from everything Larian learned while enhancing it, *Original Sin 2* is a highly polished RPG. It can take a long time to get into, the zoom level never seems to go wide enough, and the completely manual camera can hide things from you, but this detailed world is aching to be explored. **–IAN EVENDEN**

VERDICT 8

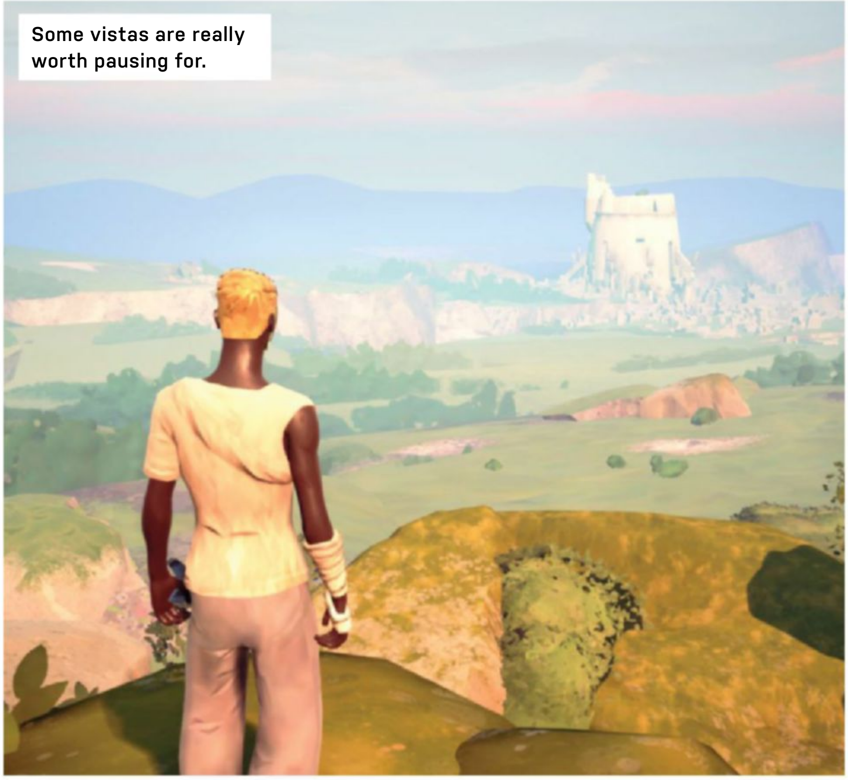
Divinity: Original Sin 2

ORIGINAL Deep, long RPG that looks and sounds amazing.

MISERABLE Slow to start; camera woes.

RECOMMENDED SPECS Intel Core i7, 8GB RAM, Nvidia GeForce GTX 770/AMD R9 280.

$45, http://divinity.game, ESRB: M



Some vistas are really worth pausing for.

Two- or three-on-one brawls are common.

You're given a mask at the start, but can find others.

Absolver

Every night's alright for fighting

WHEN IS AN MMOG not an MMOG? When it's M, and O, and a G, but not M (that's the first M, by the way, the one that means "massively"). *Absolver* would be better described as a GMOG—a gently multiplayer online game. With only a few "real" players in the same space as you at one time, and the ability to turn even this off, it's a novel way of handling PvP encounters, turning them into one-on-one duels.

Absolver is a martial arts fighting game, set in a small open world, and illustrated in one of the best, most successful graphical styles we've seen in a while. Creamy, watercolor-like washes and painterly trees mix with some chunky ruined architecture and a lovely softening effect into the distance. It's a look that will probably age well, so it's a shame that it's coupled to a game that, based on its current early showing, might not.

It's in the very nature of online games that they are patched and expanded, of course, but at the time of writing, *Absolver* has you skilling up your character by beating up newbies, in order to take out a number of sub-bosses and a big bad. There's a high-level end game, involving combat schools and the training of others, but *Absolver* is crying out for some large injections of content. We want new things to hit—and lots of them.

Combat is the heart of the game, and while you start with a range of kicks and punches, the only way to get new moves is to get beaten up by them, and learn the blows as they crunch against your skull, literally beating some sense into you. However, the only way to cement this knowledge into a move that can be added to your combat deck is to win the fight. This turns fights against those with complex moves into battles of attrition, as you fight, lose, respawn, and return to fight again.

PLAYING WITH A FULL DECK?

The combat deck is where the great depths of the game's combat system can be found; a list of attacks your character can use, which you can shuffle into combos. Attacks require stances, of which there are four, and some are exclusive to a particular stance. Switching stance also changes the direction from which you approach an enemy, so it's possible to cut around someone's guard by approaching from front-left, feinting, switching stance, and slamming a fist into the other side of their head.

Done well, it's a rather lovely ballet of violence, all sweeping kicks, flaming alt-moves, and flying fists. New styles, such as drunken boxing or those involving weapons, can be learned, changing the way you fight. Of course, forget the controls or get confused, and it becomes a button-mashing hell, and while it may be possible to win low-level fights in this way, you won't last for long without a little practice.

Absolver is deep and beautiful, capable of holding you in its clutches for the time it takes to defeat the biggest baddies. After that, there's nowhere to go, and there's not enough meat in the end-game to hold your attention for much longer. An expanded world would do the game so much good. Let's hope it's going to get one. **–IAN EVENDEN**

VERDICT 6

Absolver

ABSOLVED Wonderful graphics; deep combat system; innovative online system.

DISSOLVED Not enough to do once you've beaten everything; sparse soundtrack.

RECOMMENDED SPECS Intel Core i5-4670K, AMD FX-8320, or equivalent, 8GB RAM, GeForce GTX 960 (4,096MB), Radeon R9 380 (2,048MB), or better.

$30, https://absolvergame.com, ESRB: T

LAB NOTES

JARRED WALTON, SENIOR EDITOR

A Breakneck Pace

That was the year that was—the past 12 months in processors

2017 IS THE YEAR OF THE CPU—I can't recall a year when new product launches were so frequent. And these aren't meaningless 100MHz bumps in performance either, as both AMD and Intel have been on a roll.

To recap, Intel kicked off 2017 with the initial Kaby Lake desktop launch in January. AMD followed with its first major architectural overhaul in more than five years, with a staggered rollout of its Ryzen 7, 5, and 3 processors, and finally the beastly Threadripper. Intel also released its Skylake-X 6–10-core models and Kaby Lake-X processors, and later the 12–18-core parts, topping out with the Core i9-7980XE. And wrapping things up, Intel's Coffee Lake brings 6 cores/12 threads to its mainstream platform with new 300-series chipsets.

That's at least five major launches, complete with new chipsets, in 2017. By comparison, in 2016, Intel's Broadwell-E was the only fully new line of processors, and Intel was again the primary name in the processor space in 2015, with the launch of Skylake and LGA1151. AMD's Godavari refresh was unfortunately still slower than the FX-series Piledriver chips it launched in 2012.

If your primary interest is PC gaming, many older CPUs remain perfectly acceptable solutions, but if you're running CPU-intensive workloads, the deluge of new processors breathes new life into what has been a stagnating market. Intel claims top bragging rights in the consumer CPU rankings with the i9-7980XE and the i9-7960X, but at half the price, Threadripper is impressive in its own right.

In short, right now, it's a fantastic time to be a PC enthusiast. Everyone from the bargain hunters to the well-funded enthusiasts has something to consider. And if you're already rocking a perfectly capable processor in your machine, there are still plenty of other ways in which you can upgrade your system. Let's just hope that 2018 can keep up the pace!

INTEL CONFIDENTIAL
NA
QNFX 2.60GHZ
L719C387
M76F8K4382523

So, who won in 2017, Intel or AMD? We suspect we did, the end users.

ZAK STOREY

Deputy Editor

Mountain biking is a huge part of my life. It's a passion that I share with my father. However, I've recently been itching to push the two of us further than either of us has ever gone before, beyond the 50-mile endurance races we currently compete in.

The Mustang Madness is the name of the game, a grueling ride of over 130 miles, with a near two-mile ascent in the heart of Nepal's mystical Mustang valley. Tech is going to be pivotal for training. From quantifiable analysis of our fitness, to recording Go Pro runs, our perfectly tuned carbon-fiber bikes, and more, it's going to be an adventure to see just how far our bodies and technology, working together, can take us.

TUAN NGUYEN

Editor-in-Chief

Right now, I'm using two 32-inch 4K displays at home, running at native. That's a lot of real estate. Recently, however, I've been considering going back to just one screen. But not just any screen....

I have a Dell 32-inch 8K display sitting on my floor, just itching to be opened. The only reason why I haven't used it yet has to do with organization—two screens enable me to easily separate programs such as email, instant messaging, calendar, and other "static" utilities on one side, and have three "active" browser windows on the other. This is my preferred setup, and I've been using this arrangement for a while. Is it worth going back to one screen for 8K? Life's tough choices!

Editors' Picks:
Digital Discoveries

Bo Moore, technology editor, and Alan Dexter, executive editor, ponder their favorite peripherals

RAZER BASILISK

There's hasn't been much in the way of mouse tech that's gotten me excited in a while. Sure, DPI sensor numbers are hitting astrological levels, but for FPS precision, I tend to keep everything more reasonable. Luckily, sensors aren't the only place mice can improve themselves.

Lately, I've been playing with Razer's new Basilisk gaming mouse. It has all the high-performance sensors and such you'd expect, but also comes with some nice bells and whistles specifically for FPS players. The marquee features include a scroll wheel with adjustable resistance and a DPI clutch that lets you swap to a second DPI setting on the fly—then go right back to your primary number. The clutch is a removable magnetic paddle, meaning you can swap it out for whatever size you like (or remove it altogether), and while its default behavior is a DPI clutch, you can change its functionality to whatever you choose.

Of course, on-the-fly DPI swapping and scroll-wheel resistance adjustments are nothing new, but it's nice having all these FPS-focused features in one package. The Basilisk also uses Razer's new Synapse 3 software—I haven't dug into it too deeply yet, but it seems to be a nice update to the utility. $70, www.razerzone.com

G.SKILL RIPJAWS KM780 MX

We often wax lyrical about the latest and greatest hardware, but I'm often more interested in the gear that we use day to day. This G.Skill keyboard has been serving me well for nearly a year, and while the red key glow picks up some of the inevitable dust that it has collected over time, it still looks and acts like a premium piece of equipment.

The keyboard is available with the usual gamut of Cherry key switches, but mine employs the Cherry MX Brown switches. These aren't "clicky" like the blues, but require a bit more force than the reds. They're a happy middle ground that work as well for gaming as they do for typing, which is good, because that's exactly what I use my machine for: lots of work and plenty of play.

There are numerous features on offer, though I don't tend to use many of them on a regular basis. The lighting is set to a barely perceptible glow (no RGB lighting here, just "crimson" red), the macro recording has hardly been used, and the custom gaming keycaps survived a day before being swapped back for the standard caps. The media keys and volume control are much more welcome, though, and the general comfort means I'm not in a rush to replace it. $103, www.gskill.com

GEEK TESTED & APPROVED

Park Tool Magnetic Parts Bowl

I'VE WANTED TO TALK ABOUT this little gadget of mine for two whole years (our executive editor wouldn't let me, because he thinks it's ridiculous). It is, by far, the most useful thing I've ever purchased when it comes to my work for *Maximum PC*. So, what is it? Something typically associated with other more arduous mechanical pursuits and hobbies than PC building—it is, in short, a magnetic bowl.

Now, I know what you're thinking: "What the hell?" But just hear me out. When it comes to building, upgrading, or tweaking systems, it's generally advisable to use some sort of container to store all the nuts, bolts, and screws you're using for the job, so you don't lose them, rather than just littering them all over your workbench. A magnetic bowl goes one better, by additionally securing every metal component you throw into it via the power of magnets, ensuring you'll never lose them.

It's also pretty neat because you can attach the bowl itself to anything metal as well without worry, including cases, shelving units, refrigerators—you name it. It's simply a metal bowl, with a giant magnet attached to the bottom of it, surrounded by a rubber, err, surround—and that's all there is to it.

Additional magnetic magic includes its ability to magnetize tools. For instance, take a non-magnetic screwdriver, move it back and forth on the base of the bowl, and it becomes magnetic. Handy. **–ZS**
$10, www.parktool.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Full Drive Image
> Version Check
> Bottleneck Advice

Windows Backup

There was much good advice in your "Reinstalling Windows" feature, but I differ on the idea of doing a disk image. When I upgrade or reinstall, I take the occasion to replace the hard drive/SSD with a newer or bigger model. The old drive becomes my safety net. If the reinstall or upgrade goes awry, I simply put the old drive back and can get work done. It's also there in case I missed transferring a file I need later. Alternatively, I can reformat the old drive and use it for data backup once I'm sure the new install works. **–Rick Thompson**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: I do the same, which explains why I've got piles of old hard drives sitting around (I rarely make it to the final stage). Such a routine doesn't protect you if your new drive crashes—any work on there is gone for good—but it does mean you can have a transition period.

Minecraft on Pi

Running *Minecraft* on a tiny computer is as easy as Pi.

I just read the article on running *Minecraft* on the Raspberry Pi, and I have a question: I run the Java version on Windows 10—the most current version and recommended version is 1.12.2, with most people in my opinion scattered between 1.7.10, or 1.10-plus. Why would you recommend installing a less popular version that is no longer supported or updated? Is there something I'm missing, or was that a copy/paste from an older article? Thank you for many years of great articles and hardware reviews. **–Kyle Kroeker**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: I've just looked through the article, and can't spot a reference to installing an outdated version of Java. The closest thing was where we talked about installing SpigotMC, where we suggested installing version 1.11.2, because that was the most recent version at the time of writing, although we did state that you should install the latest version (which is indeed 1.12.2). Regardless, we always recommend that you run the latest version of all software, unless we specifically state a version for a particular feature.

Squeezing Pixels

I've been reading your July issue, Vol.22 No.8, page 95: "Bottleneck Highlight." For a long time, I wondered the exact same thing. How would you pair a CPU and GPU without physically having the parts on hand? The solution is http://thebottlenecker.com. I recently wanted to upgrade my old Core i7-870 and GeForce GTX 650 Ti, but did not know what would be the best GPU for it. Being as old as it is, I didn't want to overdo it, particularly in price. Then I found this site, and paired my CPU with a GeForce GTX 1060 3GB. Now, even this old dog of an 870 can run *Doom* on medium settings, and my GF is happy we can play more games together, having something a lot better than her ever-aging non-gaming laptop. **–Matthew Sumrada**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: That's a nice find, because it isn't a website we've visited before. The advice you get when entering your system details is fairly broad, and the problem still remains that some application-specific bottlenecks won't be picked up, but it's a good enough guide to help you spot whether your graphics card or your processor is holding you back. Some of the recommendations seem a bit off, though: If you enter the details of your upgraded system, it rightly highlights that your CPU is now holding you back, but then goes on to recommend upgrading to a Xeon E3-1270 V2—a workstation chip is a little overkill for a spot of light gaming in our books. Still, it's a good place to start.

Resolution Solution

Years ago, when I was in vocational school, I played around with CorelDRAW and Adobe Photoshop. I

↘ submit your questions to: comments@maximumpc.com always really liked working with the vector art in Corel, and it's gotten me thinking: Why doesn't Microsoft migrate the Windows desktop to a vector-based layout? Obviously, years ago, the computational power required for such a thing would have been impractical. Today, we have more than enough horsepower in even the most modest new systems to support a full vector desktop. It would eliminate most of the scaling problems that plague Windows, and raster images could be layered over the top to maintain backward compatibility. Plus, you would no longer need multiple copies of icons and fonts at different resolutions. I can't see a downside, other than the work involved in rewriting so much of Windows code. I was wondering if you had any opinions, and whether you could maybe even see what Microsoft had to say.

–James Lloyd

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: This isn't an awful idea by any means, and it could make for some very different-looking OSes. The truth is, though, that modern operating systems already have a lot of scalable elements baked in, although vector-based icons don't seem to have taken off. There's a couple of reasons why this last step hasn't been taken: one is that creating icons and interfaces would suddenly become a whole lot trickier; another is that a lot of what we do deals with raster images (movies, websites, documents, photography). There's also the fact that it isn't really perceived as a problem. Raster graphics may not be the most efficient way of building a scalable UI, but they've got us where we are today (with our sometimes clunky interfaces, font issues, and multiple-resolution icons).

[NOW ONLINE]

HOW TO STABILITY TEST YOUR COMPUTER

So, you've just spent the majority of your weekend tweaking voltages, multipliers, and the BCLK. You've gone through several blue screens, BIOS resets, and have finally managed to get into Windows—so far so good, no crashes, no stuttering.

As much as you may want to celebrate, you're going to have to resist the urge, because there is much to do before you can brag about that 2fps advantage you've just obtained. To be sure that your system is stable, you need to push it to the limit.

There are many programs that simulate a workload; most of them work equally well, but we prefer Intel's XTU. If you have an AMD CPU, you need to use another program; AMD's own OverDrive is a good place to start.

Read the full article at http://bit.ly/2yGyvSO.

Subjective Objectivity

I've written this so many times, and always stopped short of sending. I don't want to be ripped apart in your magazine. Then, in the October issue, I read the "Security Concerns" letter (Mark Van Noy), and two things hit home. First, Mark's comment regarding opinion and news. Then, I read that Linux users tend to be more clued up about vulnerability than Windows users. That's absolutely opinion, not fact, and false, in my opinion. In one broad stroke, Windows users are less educated. That really bothered me. The letter I deleted over and over dealt with a similar issue, different companies: Intel and AMD. Editorials and opinion pieces aside, even in news and reviews, the bias is staggering. I love the magazine, but enjoy the escape from our everyday climate of "better" when I read about new tech. Just my opinion. **–Anonymous**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We don't rip our readers apart, that would be foolish, and far too messy. Besides, you're absolutely right: When I responded to Mark's letter, I was, indeed, voicing my opinion. I'm sure you could find someone who's running a version of Linux who has no idea what they are doing (or, in fact, any operating system), but I still think it would be much easier to find a Windows user who is truly clueless. We share a room with the company's IT department, and the team assures me such a task would take seconds.

Essentially, not everyone is as knowledgeable about their PCs as we are. And it's nothing to do with being less-educated, more the fact that lots of Windows users are not interested in the systems they use. According to NetMarketshare, the various versions of Windows account for over 90 percent of the market, with Apple's OSes at just under 6 percent, and Linux just over 3 percent. Statistically, there are simply more clueless people using Windows.

As for bias, we can and do add opinion where we think it's needed, but we're not biased. When it comes to reviews and recommendations, we pride ourselves on being objective (well, as much as anyone truly can be, although that's a different conversation). Opinions are important; they give the world color. We could have a magazine that has no commentary at all, but it would be so bland that no one would want to read it, or write for it.

Money for Nothing

As a long-time subscriber, I wanted to express my gratitude for the ongoing coverage of cryptocurrency. I am not sure if many other readers keep older parts around, as I do, and it seems like no time has been better than now to put some of that unused equipment to use mining some (virtual) coins.

–Hans Huang

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We have covered cryptocurrencies in the past, and some of us have mined (and lost) coins over the years, too. Given that there's something of a renewed interest in the subject at the moment, we will keep an eye on it, but we find it hard to recommend seriously investing in it, because it's so volatile. Using your old hardware for the job isn't a bad idea, although such parts are lacking in terms of modern hash rates. ⏻

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THE BUILDS

BUDGET

INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Evolv ITX	$70
PSU	EVGA 450B Bronze	$45
Mobo	MSI B250I PRO Mini ITX	$80
CPU	Intel Pentium G4600	$87
GPU	MSI GeForce GTX 1050 Ti AERO 4GB **NEW**	$150
RAM	8GB (2x 4GB) Patriot Viper Elite DDR4 2400	$80
SSD	Plextor PX-128S3C 128GB	$56
HDD	1TB WD Blue 7,200rpm	$50
OS	Ubuntu Desktop Linux 16.04 LTS 64-bit	$16

Approximate Price: $634

THERE ISN'T MUCH IN THE WAY OF CHANGES this month, as our budget system sees a couple of price hikes, but little in the way of options to see us switching out for cheaper components. The one area where we did see a better deal is on the graphics card front, where our previous selection of the Gigabyte GTX 1050 Ti saw a $10 price increase, prompting us to move over to MSI for the same GPU. We also saw a price increase on the Enthoo Evolv ITX, but we're so sold on this case at the moment, that we just absorbed the $5 hike. The story of DDR4 pricing continues to frustrate, with the Patriot Viper Elites seeing an $11 increase in just a month. Unfortunately, we couldn't find anything cheaper, so ultimately had to accept that increase as well. Overall, we're looking at a total price increase of $16 compared to last month, for the exact same performance.

MID-RANGE

INGREDIENTS

PART		PRICE
Case	NZXT S340 Elite	$95
PSU	EVGA SuperNOVA 550 G2	$90
Mobo	MSI X370 SLI PLUS	$140
CPU	AMD Ryzen 5 1600	$215
Cooler	Corsair H100i v2 + bracket	$115
GPU	Zotac GeForce GTX 1070 Mini 8GB	$400
RAM	16GB (2x 8GB) G.Skill TridentZ DDR4 3200	$164
SSD	256GB Samsung PM961 M.2 PCIe NVMe	$126
HDD	Western Digital Blue Series 1TB 7,200rpm	$50
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $1,495

WE'LL PROBABLY SWAP OVER to the eighth-gen Intel Core i5 for our mid-range build next issue, but we haven't seen enough new motherboards to make the call yet, so we'll stick with our Ryzen 5 1600 build for now. In fact, there's nothing different about this build from last issue, bar a few price shifts (in the usual places). If there's nothing wrong with a build, though, there's no need to change it. It looks as though the Etherium effect is definitely behind us now, as we saw the GeForce GTX 1070 drop again, down to $400, which is only $20 more than it was before this mining nonsense started. The big price hit this month was on the memory—the G.Skill TridentZ saw a $25 price increase, and once again there were no alternatives to reach for instead. Finally, we saw the M.2 drive increase by $7. So, despite the saving on the graphics card, overall the system rolls in $17 more than last issue.

TURBO

OUR TURBO BUILD IS DESIGNED FOR those who need a seriously kick-ass system. It costs a fair chunk of cash, but you know you'll be rocking a monumental machine if you put one together. And this certainly is a system to behold—your own dream machine for a lot less than we spend each year to push the limits of system building. We're mindful of the final system price, in other words, and we always challenge any price increase in the same way that we do with the budget and mid-range machines.

This goes some way to explaining why it was so frustrating this month to discover that the G.Skill TridentZ DDR4 3200 RAM we use has seen a hefty price increase. We've seen price bumps in every build this month, but the extra $60 is not easy to swallow. The problem is, as we've seen with the other machines, that there aren't any serious alternatives worth considering. We could have saved a few dollars (we're talking about $9) to go for a less common brand, but with no guarantees that it would work with Threadrippper, we decided to stay with the sticks that we do know work. There are alternative routes we could have gone down—dropping to 4x 4GB sticks or even 2x 8GB—but neither fulfilled the first part of the Turbo mantra about producing a kick-ass machine.

There's little play in the pricing elsewhere, at least, and in fact we even saw a couple of small savings on the storage front: $4 on the 512GB Samsung 960 Pro, and a whole buck on the 4TB WD Black. The end result is still very much a kick-ass machine, it's just one that will cost you $55 more than it would have done a month ago.

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART		PRICE
Case	Phanteks Eclipse P400S Tempered Glass Silent Edition	$90
PSU	Corsair RM750X Modular Gold	$120
Mobo	Asus Prime X399-A	$350
CPU	AMD Ryzen Threadripper 1920X	$800
Cooler	NZXT Kraken X62 280mm AIO	$160
GPU	EVGA GeForce GTX 1080 Ti SC Black	$750
RAM	32GB (4x 8GB) G.Skill TridentZ DDR4 3200	$350
SSD	512GB Samsung 960 Pro M.2 NVMe	$296
HDD	4TB WD Black 7,200rpm	$185
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $3,201

UPGRADE OF THE MONTH

MSI GEFORCE GTX 1050 TI

The graphics card market has had to weather storms before, but the last cryptocurrency crisis lasted longer than any of us were happy with. Even so, it looks like the pricing on our favorite cards is just about returning to normal. To that end, if you've been putting off either building a system or finishing off the one you've been piecing together, now is a good time to complete that task. The budget and mainstream cards were most affected, so it's good to see these return to price points that actually make sense for the performance that they deliver. **$150, www.msi.com**

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